How was a billiards table lit in 1763, or the stage of the Red Bull playhouse in 1673? The earliest red and green traffic light was in London in 1868; but what was street lighting like in Paris in 1524, or San Jose, California, in 1885? How did the early U.S. settlers light their homes, and how did this compare with the homes of Sumeria 4,500 years ago, or with Stone-age lighting 15,000 years ago? How were 4,000 candles lit in less than a minute at the crowning of an English king, and what did Notre Dame look like with 1,600 fat candles burning at the funeral of a French one? How were early lighthouses lit, and how were they built? What light did they use in an operating theatre 2,500 years ago, and what were the rules for the surgeon who used it? How did Michael Angelo paint at night, and were paintings of night scenes accurate?

The answers to all these questions are to be found in this work, representing the fruits of careful historical research over many years in a virtually unexplored field. We read with horror of conditions in slave ships, warships and emigrant ships because we no longer realize that to have no light was absolutely normal below decks; just as it was equally normal not to work after dark. The effect of light, or the lack of it, on social history should provide much food for thought. It is fortunate that the subject is also full of surprises and entertainment value for the general reader as well as for the historian. The author, in order to present effectively the numerous contemporary references upon which this study is based, made a series of tests involving lengthy vigils by the lights available in the past. The result is an authoritative work that will be invaluable professionally to historians, curators and stage and screen producers.

THE SOCIAL HISTORY OF LIGHTING

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by
WILLIAM T. O'DEA B.SC. M.I.E.E.
Keeper in the Science Museum, London

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To My Wife

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Author's Note

Most of the line blocks are from drawings by the author from contemporary objects and sources

Conversions from pounds to dollars allow for contemporary variations in exchange rates

In order that each chapter may be substantially self-contained a small amount of repetition has been unavoidable

CHAPTER I

'Bad Light'

A JOURNEY to South-East Asia can be a journey into antiquity as far as lighting is concerned. In the pre-dawn hours so popular with airlines in Ceylon and India, the roads to the airports are like the passengers, just rousing themselves from sleep. The toddy shop, fluorescent lit, lies next to the ramshackle boutique in which a single 40-watt bulb makes a feeble attempt to drive gloom from the corners in which slow-moving customers wait patiently for the shopkeeper to attend them. The boutique shines brightly by comparison with the shack next door in which the only light comes from fibre wicks burning in shallow dishes of tea oil. Such fitful light from a smoking lamp would have looked old-fashioned in the wealthier homes of Ur of the Chaldees where the lamps themselves were better made and there were servants to give them frequent attention. To hundreds of millions of people today these Sumerian homes of 4,000 years ago would seem better lit than their own.

From fifteen or more millenia before Christ to A.D. 1782 there was practically no improvement in lighting at all. 'The night cometh, when no man can work' described biblically the general attitude to the hours of darkness. Man could not just go to bed. There were too many hours of darkness—an average throughout the year of twelve hours a day everywhere in the world. It was no problem in the short summer nights of Europe.

> 'When Darby saw the setting sun
> He swung his scythe and home he run.
> Sat down, drank off his quart and said
> My work is done, I'll go to bed.' [1]

In the longer nights of winter, when work in the fields had been less exacting, there was the fire to sit by, and perhaps a rushlight or a tallow

[1] *Darby and Joan*, by St. John Honeywood (1763–1798).

candle. There was no lavishness with light. Even of William Oughtred, the mathematician, it was related by John Aubrey in the 17th century that 'his wife was a penurious woman and would not allow him to burne candle after supper, by which means many a good notion is lost'. The great candle-lit balls, concerts and royal occasions were very much the exception.

It is obvious, therefore, that light—or the absence of it after dark—was a most important factor in social history. It is, however, one that has been almost completely ignored. This is no doubt due to the scarcity of references to lighting in both literature and art, and the fact that most of the references that do exist are to the unusual rather than the ordinary. Where ordinary conditions were described at all it was on assumption that the reader was familiar with the lights producing them. Moreover, where lighting was recorded by artists there was a great tendency towards exaggeration. This may have been not so much for artistic reasons as that the paintings were made in a poor light and were to be viewed by one.

It therefore seemed necessary, before embarking upon this volume, which represents researches over many years, to undertake some more practical investigations into various lighting devices. It was not difficult to get old lamps, fill them with oils not dissimilar from those formerly available, make up wicks of twisted fibre or greasy rag and compare results with the aid of modern instruments. Candles presented more difficulty, for wax and tallow deteriorate over a substantial period of years and it was therefore necessary to have new candles made up as nearly as possible by old-time methods. In this grateful acknowledgment must be made to Prices Patent Candle Works of Battersea, London, which is one of the oldest as well as the largest maker of candles. The results of tests involving lengthy vigils, in which the only thing to do was to use what light was available for reading or writing by, were to make clear many references that were otherwise puzzling and to provide not a few surprises. A brief estimation based on experiences with each of the early forms of lighting may appropriately be given before passing on to an attempt at describing to what extent and with what results they were employed.

The primitive oil lamp was quite easy to manage and the light it gave was of the same order as that of a good tallow candle. Refinements on the simplest shape, the open saucer, were basically refinements in management rather than in light. The turned-over lip prevented spillage of oil, if the lamp were accidentally disturbed. The wick-channel kept the flame in one place and enabled a certain amount of downward

lighting to be enjoyed. The completely enclosed lamp kept the oil from adulteration by dirt or flies. The oil itself could be anything—fish oil, vegetable oil, mineral oil. Much of it was a by-product, and the degree to which it was refined or to which it avoided noisome products of combustion was the principal measure of its excellence. Fish oil was inclined to stink; the better vegetable oils were practically odourless. Most oils, before mineral oils became common less than a century ago, gave pretty much the same light. They were all edible, and in times when food was scarce there might be little to spare for light. Food, in the humbler homes, was often scarce.

The tallow candle, by comparison with these oil lamps, seemed to me a wretched and infuriating device. Tallow was also edible, as the Elder Brethren of Trinity House, responsible for the lighthouses round the coasts of Britain, discovered to their annoyance. The lighthouse keepers were extremely prodigal in the use of the candles provided for the lights and it was found that they used them to supplement their meagre rations. As food they were more sustaining than attractive, and the same could be said of the way in which they provided illumination. They gave a light initially less than that of a beeswax candle, which deteriorated rapidly as the candle burned on. Snuffing was supposed to be necessary every half-hour with candles of best London tallow. With those that I tested the operation had to be done every twenty minutes and in some cases was necessary after five. An unsnuffed candle gave not only a fraction of the original light, but great gullies might appear in the pool of molten tallow beneath the flame. The molten tallow would pour down such a gully and in one candle left untended only 5 per cent of the tallow was actually burnt and the rest ran to waste. A candle of 8 to the pound was completely consumed in this way in less than half an hour; but even with constant snuffing it proved not unusual to lose more than half the tallow by 'guttering' (the term by which the pouring away process was known). Pepys, in 1663, 'begun to burn wax candle in my closet at the office, to try the charge, and to see whether the smoke offends like that of tallow candles'. The result is not recorded, but from my own similar tests wax has it every time.

'Snuffing', by which is meant the removal of an end of charred wick before it could fall into the molten tallow and cause 'guttering', was a process requiring dexterity and judgment. This I never acquired; but my experience was not extensive and the record of Dr. Johnson's Boswell, who must perforce have repeated the operation thousands of times, disclosed that familiarity should not have bred contempt.

'I determined to sit up all this night,' said Boswell on one occasion in 1763,[1] 'which I accordingly did and wrote a great deal. About two o'clock in the morning I inadvertently snuffed out my candle, and as my fire before that was long before black and cold, I was in a great dilemma how to proceed. Downstairs did I softly and silently step to the kitchen. But, alas, there was as little fire there as upon the icy mountains of Greenland. With a tinder box is a light struck every morning to kindle the fire, which is put out at night. But this tinder box I could not see, nor knew where to find. I was now filled with gloomy

Fig. 1.

ideas of the terrors of the night. I was also apprehensive that my landlord who always keeps a pair of loaded pistols by him, might fire at me as a thief. I went up to my room, sat quietly until I heard the watchman calling "past three o'clock". I then called to him to knock at the door of the house where I lodged. He did so, and I opened to him and got my candle re-lumed without danger. Thus was I relieved and continued busy until eight the next day.'

A couple of centuries earlier the difficulty of re-luming was also referred to by Cervantes (*Don Quixote*, Part I, Ch. XVI). After an innkeeper had deliberately extinguished the lamp an officer seeking a light by which to arrest disturbers of the peace could get one only by

[1] Boswell's *London Journey*, 1762–3. Edited by Frank A. Pottle, 1950. London, William Heinemann; U.S.A., Yale University.

going to the hearth where he raised one after much time and trouble. Undoubtedly the fire, covered in ashes, had first to be blown into activity.

It is no wonder that 'snuffing' has come to mean extinguishing. The scissors with box-like contrivances in which the cut-off ends of charred wick are held, are snuffers. The design, with variations, lasted for three centuries. Snuffers were quite expensive and in the time of Charles II imported snuffers carried the considerable tax of eightpence each. The little conical iron caps so often called snuffers are extinguishers. Another comment on snuffing was provided by Goethe:

> '*Wusstes nicht was sie besseres erfinden könnten*
> *Als wenn die Lichten ohne Putzen brennten.*'[1]

He may have been referring to, or at least including oil lamps in this remark for while they were much easier to manage than tallow candles

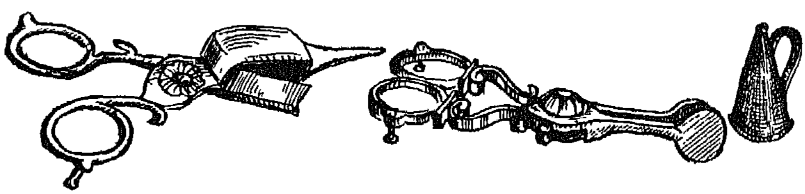


Fig. 2. Snuffers. Douters. Extinguisher.

they were still a nuisance. The wicks had to be pulled up with spikes or forceps from time to time, trimmed when necessary and the lamps themselves had to be cleaned out when the remaining oil became a sludge compounded of oil, dirt, flies and charred matter. Roman bronze lamps often had spikes attached by a chain and in the 17th and 18th centuries brass lamps in the Low Countries were frequently bedecked with a variety of hanging hardware. There were spikes, forceps, buckets to contain the snuffs and little conical caps as extinguishers. In addition there might be adjustable brass plates to cut out glare and douters for extinguishing without smoke. Douters were simply scissors with flat circular ends within which the wick could be pinched.

Even these lamps with the implements and accessories chained or clamped to them so that they could not be mislaid, might run short of

[1] 'What better discovery could there be than a light that burns without trimming.'

oil. Shakespeare, who so often went to ordinary domestic affairs for his similies, refers frequently to the oil-starved lamps:

> 'These eyes
> Like lamps whose wasting oil is spent
> Wax dim.'
>
> Mortimer, *I Henry VI,* ii.5.
>
> 'Let me not live, quoth he
> After my flame lacks oil, to be
> The snuff of younger spirits.'
>
> *All's Well,* ii.5.
>
> 'My oil dried lamp and time bewasted light
> Shall be extinct with age and endless night;
> My inch of taper will be burnt and done.'
>
> Gaunt, *Richard III,* i.2.

There were relatively few disadvantages in the well-made beeswax candle. 'Well-made' is an important qualification. Too large a wick would mean too great a rate of combustion and the wax would not melt quickly enough to feed the flame. In that event the candle smoked. Too small a wick meant that more wax was melted than could be consumed, and the surplus wax ran down the candle. The matching of wicks was a matter of considerable skill and any beeswax candles were three times the price of tallow. Nevertheless they could be left for hours without any attention at all, and were thus almost obligatory for any dances, court functions or theatre shows on a lavish scale. Pepys recorded a conversation with Killigrew, the manager of the Drury Lane Theatre, London, in February 1667:

'He tells me that the stage is now, by his pains, a thousand times better and more glorious than heretofore. Now wax candles, and many of them; then not above 3 lbs. of tallow.'

In the days of tallow it was nothing for a snuff boy to come before the audience in the middle of the most emotional scene in order to tend a smoking candle. His entrance would be ignored, but his skill might be recognized by a round of applause that must have restrained any tendency towards self-importance in the play-actors.

There is a common impression among historians of lighting that the introduction of the 'snuffless wick' by Cambacères in 1820 was one of those belated inventions which might have been made centuries earlier with incalculable benefit to mankind. This is not so. It was only in conjunction with the newly discovered fatty acids (stearine) that the

plaited wick proved self-consuming. Later, when paraffin wax came in, it was equally effective. With lower melting-point tallow the wick would still bend over into the outer, hot edge of the flame but the tallow would be melted by the low flame faster than the wick could consume itself. The result, if such a wick had ever been invented, and it may well have been, would have been guttering of the most serious kind.

A common light that has not yet been described is the rushlight. It was simply a length of prepared pith, dried and dipped in any sort of tallow. It gave quite a good light, equal to that of a tallow candle, but it burned away fast and distributed a line of greasy drops below the path of the flame. It was burned in a nearly horizontal position, and although a new rush had frequently to be inserted in the holder this seemed on test to be no more burdensome than snuffing, as the pith wick was entirely self-consuming. The rushlight was extremely cheap, but it was not popular. Gilbert White of Selborne, the famous naturalist, was furious with the country people for being so improvident as to burn dearer candles. As far as my tests went I did not share their preference, and I suspect that my tallow candles must have been less well made than they were in olden times or else that my management of them was very unskilled. Perhaps the lines of grease left behind by rushlights were more of an annoyance to the regular user than they were to me. The poor of those days should not, I should have thought, have been so particular. Shakespeare's kitchen maid (*Comedy of Errors*, iii. 2) inevitably comes to mind:

> 'Marry, sir, she's the kitchen wench, and all grease; and I know not what use to put her to, but to make a lamp of her, and run from her by her own light. I warrant her rags, and the tallow in them, will burn a Poland winter.'

To the family accustomed to cooking before the fire; to dairying or mucking out the stables in their one and only suits of workday clothing; to bathing seldom and living in earth-floored hovels a bit more grease about the home would hardly have seemed to matter. Nevertheless the rushlight was suffered less willingly than the candle.

It is therefore clear that lighting devices, up to early in the 19th century, were all more or less the same for the light they could give; were inclined to deteriorate at varying rates upon which to a considerable degree their price depended; were conversely in need of more or less frequent attention; and were usually messy and dirt-producing. The cheaper light fuels were, in addition, smelly. A great multiplicity

of lights generated a great deal of heat and consumed vast quantities of air (an important point in a theatre, for instance). The sort of light that could be obtained in a room furnished with these devices is more difficult to describe.

Comparisons between, say an electric filament lamp of so many watts and a number of candles reckoned to produce the same total light output are not valid. A single candle may produce only one-hundredth as much light as a 60-watt lamp bulb; but one hundred candles would light a room in a different way. A room forty feet by thirty could be lit quite cheerfully by the candles and would be dismal by the light of a single bulb. The reason is the 'square law' so well known to anyone who has studied physics. Ten feet away from a light source the illumination per unit area is only one-hundredth of what it is one foot away, and so on. Candle flames are surprisingly bright although the total light output from a candle is not great. Close to a candle the light can be uncomfortably bright; and the fact that small screens to protect the eye from glare used to be not uncommon, shows how, when there were not the high-intensity artificial light sources to which we have become accustomed, the candle was not looked down upon as a dim and unsatisfactory source of illumination.

In the succeeding chapters there are many contemporary references to brightness that sound astonishing to people conditioned by high-pressure discharge lamps, fluorescent tubes and even electric filament lamps. The paraffin vapour lamp with an incandescent mantle far surpasses anything known a century ago. When Dona Rodriguez, bearing a candle in her left hand, entered Don Quixote's room at night she shielded the candle flame from her face with her other hand. In this way she would be able to see much better the dimly-lit room as the acuity of her vision would be less reduced by glare. What can we make of the writer[1] who, in 1651, described the use of a water-filled spherical flask as a condenser lens in conjunction with a candle flame under the heading 'How to make a glorious light with a candle like sunshine'. It was this sort of description that made experiments with old-time lighting media so essential.

Not all ancient commentators were given to exaggeration. There are many references over many centuries to inability to distinguish colour graduations in a bad light: 16th century John Heywood said 'at night all cats be grey' and three hundred years later Elizabeth Barrett Browning was able only to put the same observation in less succinct form:

[1] John White: 'A rich cabinet with variety of inventions.' London, 1651.

'Colours seen by candle light
Will not seem the same by day.'

Artists, in general, avoided night scenes for just that reason. Some, like de la Tour, were fascinated by the subtlety of the candle-lit scene, which they depicted repeatedly. Joseph Wright of Derby supplied his own imaginative colours. His paintings bore little relation to what could actually be seen by the lights available in his day. Others, like Pannini, painted scenes by daylight and added lighted candles with no attempt to make them seem like the actual light sources. Not many contemporary night scenes have been found after searches lasting many years and covering many countries. Of those found only a small proportion actually show the light sources and numbers of these have been weeded out as representing too great an exaggeration over the conditions discovered during the tests already described. A selection from those judged to be reasonably accurate representations of contemporary scenes has been used as illustrations.

By the author's standards most of Rembrandt's pictures would hardly qualify for inclusion. Like Joseph Wright of Derby he painted just a little too dramatically. The lighting available to Rembrandt has been copied experimentally and the effects studied, and there is little doubt that his contrasts have been greatly heightened if they are viewed in a bright light. It is most probable that such pictures were not only painted by candlelight but were intended to be viewed by candlelight. In that event the low intensity of light would reduce the contrasts that seem excessive by daylight. 'The Night Watch', for instance, was commissioned by a number of prominent citizens and would be viewed in a candle-lit or lamp-lit dining-hall on the occasions that they and their successors met. It is detrimental to the balance intended by the artist to see it by too bright a light, and although some care has been taken in Amsterdam to exclude direct daylight, it is nevertheless seen under conditions that probably do it less than justice.

The 15,000-year-old paintings in the Lascaux caves in France would suffer similarly if they were too brightly lit and even now their lighting seems too bland to reproduce to the full the dramatic impact experienced by the initiates who viewed them by the light of flickering grease lamps.

Some of the works of art that have been used as illustrations seem to be of exceptional fidelity. One of the best is the scene in the cellar of an inn painted by Gottfried von Schalken (1643–1706) (Plate 1); and one of the most impressive the church lit by hundreds of candles at the

christening of the Duke of Södermanland, as depicted by Elias Martin (1739–1818) (Plate 2). The search for such pictures has been far from easy, and only occasionally rewarding. Many people have helped with information; but all too often the sources of light were not shown or else the picture lacked conviction as a true representation of actual conditions. It required discipline to spend hours in the Louvre, for instance, refusing to be distracted from what proved in the end to be an almost unrewarding search by the magnificent paintings before which the desire to linger was almost irresistible.

It has to be remembered that the artist in these cases had only two alternatives—to paint by the same indifferent light that he was trying to depict, in which case the picture might look somewhat dull when viewed by the bright light of day; or to paint by daylight and hope that he had recollected accurately the night-time scene. Whistler used to visit the scene and content himself with a few rough sketches of fire-works exploding, or of lights. The next day he worked in his studio. Holman Hunt, on the other hand, when painting 'The Light of the World' (now in the chapel of Keble College, Oxford) is said to have done his experimental work and actual painting outdoors at night. Painting by candlelight was quite possible. It was recorded of Gainsborough that he and his nephew once painted the dress of Queen Charlotte, wife of George III, in a single night by the light of candles; and this in a portrait to be viewed in and as of daylight. Michelangelo, when painting his 'Last Judgment' in the 16th century, devised a holder for a stout candle held on top of his head. The most extraordinary achievement of all was probably that of de la Tour who depicted the restless flames of the flambeau in his 'St. Sebastian' at the Stadtsmuseum, Berlin, (Plate 2) with a fidelity that is almost unbelievable for anyone without the advantage of the modern high-speed camera for observation.

The fact that illuminants, however ineffective or troublesome, were known at any particular time did not mean that they were freely available. For the great occasions of the very rich there might be a prodigal burning of wax in tremendous quantities. For the ordinary occasions of the reasonably well-off there was no prodigality; and a family of moderate means might be economical to the point of parsimony. At Haworth Parsonage, where the living was worth £200 a year with an extra £1 a week from Mrs. Bronte's personal fortune, there was no extravagance in the year 1827:

'Having just concluded a quarrel with Tabby (the old servant), wrote

Mrs. Gaskell in her life of Charlotte Bronte, 'concerning the propriety of lighting a candle, from which she came off victorious, no candle having been produced. A long pause succeeded, which was at last broken by Bramwell saying, in a lazy manner 'I don't know what to do'. Which was echoed by Emily and Anne.'

In the same work, under the date Christmas 1836, there occurs:

'It was the household custom among these girls to sew until nine o'clock at night. When their duties for the day were accounted done they put away their work and began to pace backwards and forwards, up and down—as often with the candles extinguished for economy's sake as not—their figures glancing into the firelight and out into the shadow, perpetually.'

It was perhaps little wonder that by 1850, although Charlotte was then a famous authoress, 'her weak eyesight rendered her incapable of following any occupation but knitting by candle-light'.

This reluctance to squander light has become so ingrained that many people, with electricity freely and cheaply available, will still indulge in the most needless economies such as putting low-power lamps in toilets where the daily use is so small that a high wattage lamp would cost only a penny or two more every year. This atavistic reaction is not a matter of income. Parsimony with light has long enough been common at all levels of society and not only the miser in Gogol's *Dead Souls* was typical of inhibitions among the wealthy. Take, for instance, a yeoman with £800 a year in 1791. That was a really handsome income, but the son of the Reverend George Crabbe, who was his father's biographer, records a visit to his great-uncle at Parham in Suffolk in the following terms. On most occasions, he said,

'the family and the visitors lived entirely in the old-fashioned kitchen along with the servants. My great-uncle occupied an armchair, or, in attacks of gout, a couch on one side of a large open chimney. Mrs. Fovell sat at a small table, on which, in the evening, stood one small candle, in an iron candlestick, plying her needle by the feeble glimmer surrounded by her maids, all busy at the same employment; but in winter a noble block of wood, sometimes the whole circumference of a pollard, threw its comfortable warmth and cheerful blaze over the apartment.'

Much earlier, in 1571, Thomas Tusser included candles among the

objects about which the thrifty housewife should be warned. Of candles, spice, fire and sweet sauce he said:

'these fower rob chest.'

Mrs. Fovell's candle allowed her and the servants to ply their needles, but work at night, with that exception, was not common until the early 19th century when it was carried out under the most deplorable conditions. Journeys at night were avoided at times when the moon was dark. Flaubert, writing in the 1850s, described how Dr. Bovary waited several hours for the moon to rise before starting cross-country on horseback to attend to a farmer who had broken a leg. Battles were discontinued at sunset and patients lying in hospital were well-advised to require no attention or surgery after nightfall. Labourers, children and animals returning from the fields at dusk were referred to by Sappho of Lesbos in the 7th century B.C.:

> 'Evening, thou that bringest all, whatever the light-giving dawn scattered; thou bringest the sheep, thou bringest the goat, thou bringest the child to its mother.'

The Reeve's Tale of Chaucer depended for its robust humour on situations that could only have been contrived in the absolute darkness of a communal bedroom. There was no switching on and off of lights and even no question of kindling a light with flint and tinder. There was darkness, and in that darkness the sleepers had to stay until, in the words of Milton:

> 'Morn,
> Waked by the circling hours with rosy hand
> Unbarr'd the gates of light.'

The closing down of activity at night has been described many times. The succeeding chapters of this book endeavour to show what could be done despite the poorness or scarcity of illuminants. Trevelyan's well-known *Social History of England* fails to mention lighting, but as a factor in the social life there is no question about its importance. Fortunately, as history, it is also quite entertaining.

Daylight, in any part of the world, averages twelve hours out of the twenty-four throughout the year. So does darkness. In the tropics there is little difference between summer and winter. At the poles there is theoretically six months of light followed by six months of darkness. It is not quite so bad as that for the stars, the moon, the aurora borealis and a dusk in the extreme months of the dark period relieve the situ-

ation slightly. Nevertheless in Sweden there is great tolerance in the South of the peculiarities of the Laplander from the North if he comes down shortly after several months of dark or near-dark. I have heard a Laplander in a Stockholm bus in May talking merrily to himself while pointing out the sights, entirely for his own satisfaction. Nobody seemed to regard this as at all unusual. It is now becoming so easy to relieve darkness that such tolerance may wane, and the world may not be the better for it.

The first form of artificial light was the fire. It gave warmth and frightened away beasts of prey, but some remote ancestors of man discovered that they could also mend a flint axe or a spear, or flay an animal by its light. All is conjectural at this period. A brand snatched from the fire to hurl at some too inquisitive beast may have developed

Fig. 3. Fires and fire brands in remote antiquity. Stone and shell Lamps.

into the torch. A carcass left too near the fire may have been cooked while the hunter slept. The smell and flavour may have been attractive enough to lead to a conscious repetition of the experiment. The brightness of the burning fat may have been a matter for wonderment. A fibre burning in a pool of molten fat may have led some prehistoric genius, or even a succession of them, to the invention of the lamp. We do not know; but we do know that the Lascaux cave paintings in France have been attributed confidently to a date about 15,000 years ago and that in those caves a hundred stone lamps have been discovered.

This early manifestation of an advanced artistic culture would have been impossible without these lamps, as the caves were wholly dark a short distance from the entrance. The paintings were certainly done by lamplight. The culture represented must have required a very long time to develop into such sophisticated forms. It is therefore conjecturally reasonable to suppose that earlier man found that he could extend the useful period of daylight by modelling, painting or doing domestic

tasks by the light of the fire in the cave or at its mouth. During daylight hunting for means of existence would have left him little leisure time so that a way of using the night hours was of great value. We may therefore presume that some of the earliest steps in the civilization of our wild and primitive ancestors were influenced by or even attributable to the existence of means of illumination by night.

It is difficult to deal with lighting in exact chronological sequence as stone, bronze or iron-age cultures which seem so remote to European and American city dwellers are still to be found or have been modified only recently in many primitive areas of the world. The Eskimo, with his blubber lamps for lighting, heating and cooking, was at a stage of development within living memory little removed from that of the men of Lascaux. The tea-oil lamps of the Indian peasant give a light no different from that of lamps 4,500 years old discovered at Mohenjo-Daro in the Indus valley, but in many villages there are now to be found hurricane lamps and paraffin pressure lamps. There are vast plans for electric supplies on the Guinea Coast but a great impression on at least one recent traveller in Nigeria was made by the primitive lamps of Ibadan:

> 'It looks its best at night. By the door of every close-packed dwelling, at every booth lining the streets, glows a candle or home-made oil lamp, each throwing its little nimbus of light into the warm air. The whole centre of the town is aglow, as if the Milky Way had floated down to earth. All ugliness and dirt are hidden. A gentle light flickers on bronze cheek bones, shadowed eyes, on slim wrists and fingers.'[1]

An attempt will therefore be made to give a conspectus of social history as influenced by means of illumination, leaving to the reader the task of recognizing the social significance of much of the information presented in the more detailed chapters that follow.

Just as there are today backward communities in every continent, so must the development of civilized amenities have been very uneven in ancient times. The simpler conveniences were probably invented independently many times in many places and although such inventions may have spread from community to community, with local modifications as different skills and materials were brought into service, there is little doubt that grease lamps made from hollow stones or shells were developed quite independently into carefully manufactured lamps in many parts of the world.

The earliest manifestations of lamp fabrication apart from hollowed

[1] Elspeth Huxley: *Four Guineas*, Chatto & Windus. London, 1954

and shaped stones all date from approximately the same period, namely 3,500 to 2,500 B.C. It may be objected that 1,000 years is too long a time to be treated as a whole. There is force in such an argument although the period in question cannot be equated with that between A.D. 0–1,000, and the tempo rose with incomparable rapidity between A.D. 1,000 and the present time. Nevertheless, 1,000 years gives time for inter-communication even though there may have been no records, poor facilities, and indifferent standards of achievement. Knowledge, or 'know-how', was largely empirical at this time and the successive

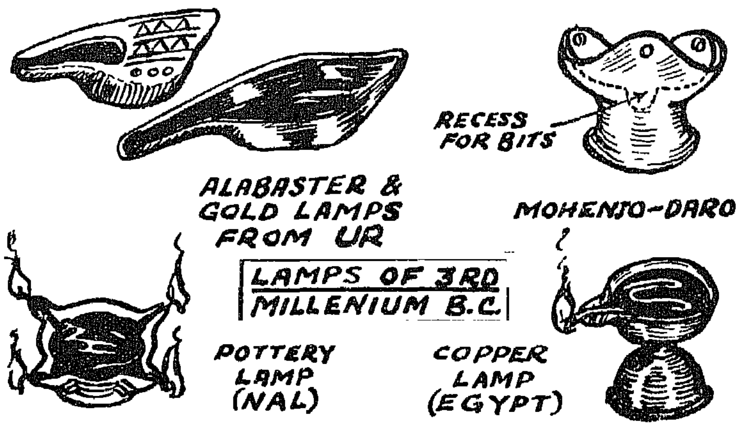


Fig. 4. Lamps of 3rd millennium B.C.

civilizations over the best part of a millennium in Chaldea alone impacted upon one another even though they remained very distinct in individual characteristics of their productions.

In the period of 1,000 years from 3,500–2,500 B.C. there are manifestations with evidence of inter-communication from Palestine and district, the Indus valley, Sumeria and Egypt roughly in that order, as far as excavations up to the present time have revealed. The area is the centre of the ancient world and may justly be described as the cradle of civilization. China, the home of so individual and advanced a culture, comes into the picture more than half a millennium later. The lamp as a domestic convenience was developed during these centuries but the extent of its application cannot be defined. It is probable that the more elaborate lamps in alabaster, bronze or gold were extremely rare. Earthenware lamps or lamps made from sea shells may have been common and the oil to feed them abundant. Apart from vegetable oils

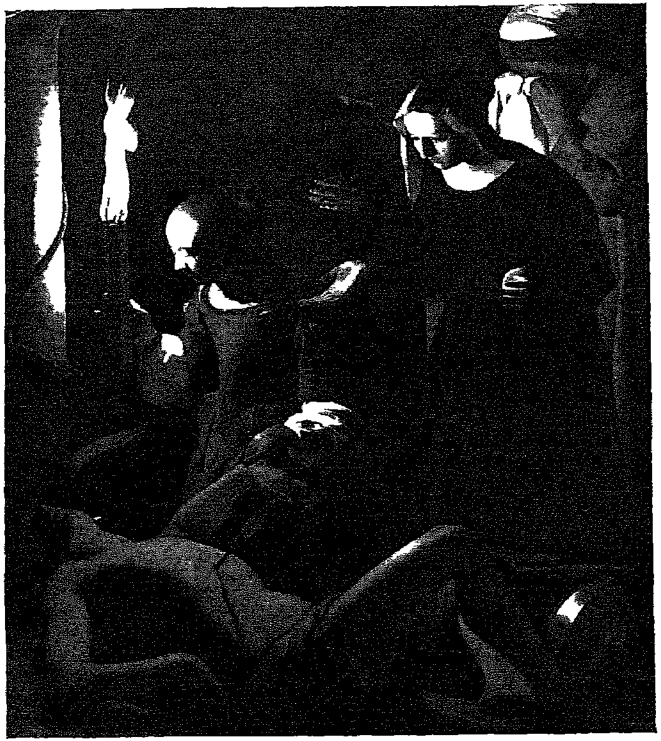
(and olive oil was specified for the seven-branched 'candlestick' described in Exodus) there was fish oil in maritime regions and the crude natural seepages from petroleum deposits in Sumeria. Of these periods in antiquity there is not enough evidence on which to be confident in estimation. In ancient Babylon thick tow wicks in bowls containing a half-hundredweight of grease were features in the streets at festival times. That might imply a measure of similar lighting on a smaller scale in the homes at other times, but as with the Christian feast of Candlemas (which was itself a substitute for the Roman fertility celebrations of the feast of Lupercalia) the primary reason for prodigality with light was to emphasize the unusual nature of a great occasion.

When we jump a couple of millenia to the 3rd–5th centuries B.C. we are on firmer ground. The American School of Classical Studies in Athens has unearthed the remains of over 10,000 lamps. This must represent only a small fraction of the lamps actually in use during the period and there can be little risk in concluding that domestic lighting was at the time on a far from negligible scale even though the population varied between 300,000–500,000 (of whom about half were slaves). In Roman times, for some centuries immediately following the Greek period, the production of pottery lamps was on a very large scale. Lamps were commonplace and elaborate models in bronze differentiated the patrician user from his fellows. Even the slaves used snail shells with a tow wick and vegetable oil. It would be satisfactory to record that civilization in Roman times advanced by leaps and bounds as a result of this great advance in the use of illuminants. Unfortunately it must be recorded that the Roman citizen preferred the companionship of the town square and public buildings to the seclusion of his home and it is more than probable that civilization owed more to his gregarious habits and consequent verbal disputation than to his expenditure on lamp-oil for study. He did not, however, stray far from his home at night, but preferred to rise before dawn.

Nevertheless it is to the Romans that we seem to owe the candle, the horn lantern and the wax torch known in later centuries as the flambeau. The candle may have been used domestically, but the horn lantern and flambeau were aids to travel by night and as such were welcome to the wandering citizens of Rome. The strapiron or earthenware 'cresset' in which burned a small fire of tow and pitch, or pine cones at the top of a torch stave, was also an aid to the nocturnal wanderer. After a theatrical performance hundreds of slaves with torches would be employed to light home the favoured spectators. The Romans did not make appreciable use of artificial lighting for either work or study. A

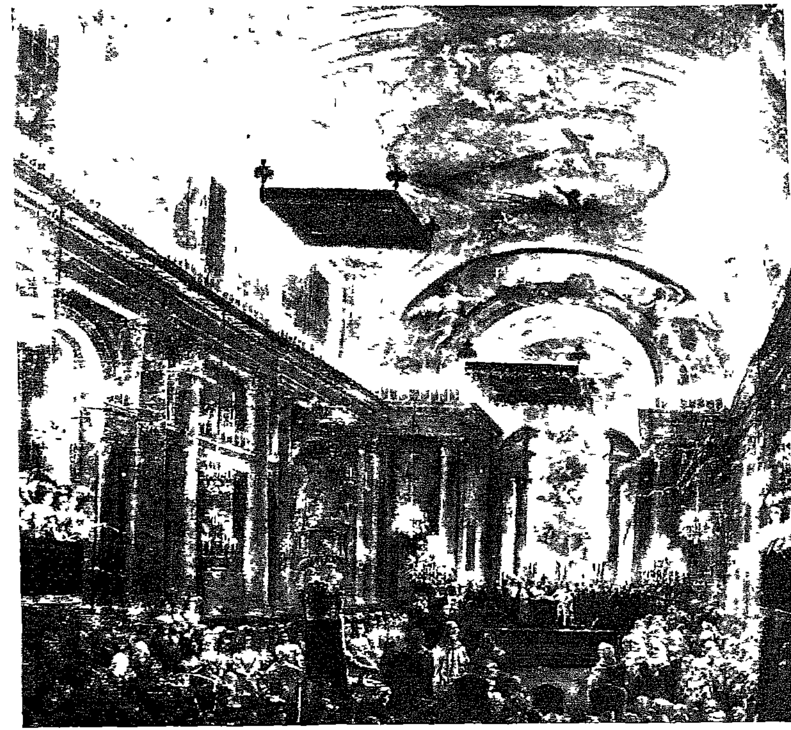
Girl at an Inn, by Godfried Schalken (1643-1706)

Property of F. N. Salaman



St. Sebastian by Georges de la Tour (1593-1652)

Staatliche Museum, Berlin



Baptism of the son of Gustaf III of Sweden. By Elias Martin

Drottningholm Castle Collection

perpetually maintained lamp was kept before the altars of the domestic gods, but probably more to prevent accidental desecration in the dark than in the votive sense that later became common among Christians.

The candle was a comparative late-comer to illumination of which the earliest positive evidence dates only to the 1st century A.D. The early candles were regarded as inferior substitutes for lamps. From Rome the emphasis on lighting seems to have passed to the Middle East by the 4th–5th centuries A.D. in which there are records of lamps suspended outdoors by ropes in Antioch, wood fires at cross-roads in Jerusalem and bleached wax candles in the Byzantine Kingdom of Constantine. There followed, for the best part of a millennium, the dark ages during which lighting was certainly used in churches, both candles and lamps, but the extent to which it was used for secular purposes is difficult to estimate. The fire and the torch leave little trace behind, and records are of the scantiest. Cardenio, in *Don Quixote*, describes the hall of Lucinda's house as lit by torches at her betrothal. By the light of one of them he read a letter that she had concealed. The word curfew is derived from the Norman-French 'covre-le-feu' which seems to imply that the peasantry at least, who were subject to such restrictions, lost the light by which they could see after dark when the time came for the fire to be dowsed. In more exalted circles the thick stone walls and stone floors of castles were in themselves fire-proof while furniture was mainly tables, benches and chests in solid wood that would be slow to catch fire. Hangings were few, but the practice of strewing the floors with rushes seems to have introduced an element of danger into the use of torches. It is known that on great occasions the torches were held by torchbearers rather than left to burn unattended and the fire-risk may well have been the reason. Pinewood torches were particularly liable to shed glowing embers and to exude sticky carbon particles that would quickly have ruined hangings if it had been the custom to leave tapestries or fabrics permanently exposed to view. Oil lamps were only a stage less troublesome. Vitruvius remarked on the dirt they deposited on cornices and hangings. In Rome a slave was usually detailed to wash down the statues after a lamp-lit party. Moreover capillary leakage of oil could make a mess where the lamp had been standing.

The most brilliant individual light sources were, in order of brilliance, the fire, the flambeau and the wick-channel pan lamp. They were also, in the same order, more likely to flicker and to smoke. The wick-spout oil lamps or the candle could be almost smokeless except when used in

draughty situations. The candle, particularly, was very variable in quality and in the amount of attention it required but it could be placed exactly where it was most effective while the fire was almost inevitably confined to the place where it was most inconvenient as a source of light. The fire, which was wanted for warmth and cooking, became a not inconsiderable bonus in the lighting sense. It gave a measure of general illumination while supplementary lights, if they could be afforded, gave light where more was needed.

Rabelais in the prologue of *Pantagruel* suggests that 'three dead stones' in the middle of a porch were to act as extinguishers for candles, torches, tapers, rushlights and flares, as in the game of 'snuff it out'. Flambeaux, which burned so fiercely (and so expensively) that they could resist all but the worst winds and rains, were almost wholly used for journeys outdoors although Cotgrave, in 1611, said that they were 'used for state in the houses of the great men'. In the garden float-wick lamps in deep glass jars or candles in deep, bell-shaped glasses, gave a pleasant light that would persist in gentle winds. Horn lanterns gave a light too shadowed for social occasions outdoors but were much used by individual travellers. They were much more economical than flambeaux but were much less effective for lighting. Street lighting was almost unknown and in London and Paris was very ineffective for the first three centuries of trial from the 15th century onwards. A retinue with accompanying flambeaux carriers was much less easy to surprise than a man with a horn lantern and it was in the dark streets that enemies and footpads lay in wait.

Light for work was not in great demand. Most people, up to quite recent times, were illiterate, so that reading or writing were practised only by the few. The few were usually either of the richer class who could afford the expense of lights in the home, or churchmen. In the humbler rooms or households simple tasks such as rough sewing or rough woodwork could be done by firelight while the family or servants repeated old tales or discussed the events of the day. Early to bed was the general rule, but for close work or for the second room of the peasant hovel, if it had one, a rushlight or a tallow candle might be wanted. These were home-made, often communally, and surpluses might be sent to the towns where they were cheap enough for the moderately poor. The simple lamps were a variant for which the peasant might provide his own vegetable oils, fish oil or even tallow. A candle or lamp would not light a whole room effectively but it would light up the work if it was brought close enough.

Where a large area had to be lit the problems took on a different

significance. Tallow candles needed frequent attention, and a candle that did not get it as soon as it began to gutter might fill the room with unpleasant-smelling smoke, and melt away at an alarming rate. A dozen tallow candles would need what seemed to be constant attention, and a hundred might be more than enough for one man to manage. As numbers went up, so did other factors to their detriment. A hundred tallow candles might give out an uncomfortable amount of heat and rob the atmosphere of more than a fair share of oxygen. Each candle consumed as much as two men according to one authority and in the process substituted a noticeable smell. A hundred candles could hardly be bestowed around the room with the ease of ten, and some of them might well be in positions to which the necessary and frequent access by an attendant was a matter of considerable difficulty. The crystal chandeliers slung high in the great salons of the 18th century are good examples of this inaccessibility.

It was therefore almost inevitable that the rich, who were the only ones that could afford large-scale lighting anyway, should have found it essential to provide themselves with the most easily managed lights, regardless of the greater expense. Tallow was clearly inadequate and oil lamps had the disadvantage that they were not easy to place and their opacity and shape were such that they cast formidable shadows. The beeswax candle was very much better and so beeswax, already demanded for centuries by the Church, became more or less obligatory for great secular occasions. The rate of consumption of the higher melting-point beeswax was considerably less than that of tallow, and this fact alone increased the period for which the candles could be left unattended. The large diameter beeswax candle (such as the paschal candles used in churches at Easter time) could be left indefinitely, but in the main the candles used for festive occasions were relatively slender. They would last with only slight loss of efficiency for hours at a time without attention and even if they smoked and guttered they were far less objectionable than tallow. Tallow came in various grades, but even the best was near to the minimum standard of bearability and was of so low a melting point as to be virtually unusable in any but temperate or cold climates.

The very rich used wax candles whenever the occasion might be held to justify such extravagance, or lamps burning the finest oils. The less rich used such luxuries only on very special occasions. Prodigality was not the rule. At a great house such as Audley End in Suffolk the records show a daily consumption of little over three pounds of candles during the winter months of 1765. Moreover purchases for cash were rare if

the estate could provide; so even these few candles were of tallow and not of wax. Servants of the rich had tallow or inferior oils and the middling well-off family would join them in the use of tallow at less than a quarter the cost of the best wax candles. The poor might have tallow dips, if tallow were plentiful, but the rushlight was the poor man's candle. They cost, in terms of hours of light, only a fifth as much as the cheaper sorts of candle. Money was not freely spent on light. If fish oil was in abundance, fish oil was used. The smell didn't matter. In the hovels of the poor one smell more or less would hardly be noticed.

The emergence from the Dark Ages began to take recognizable shape in the 11th and 12th centuries from which some elaborate lighting fittings have survived. Even as early as the 8th century there was a sanctuary lamp at St. Peter's in Rome bearing a total of 1,370 lights, but it was not until the 13th century in France and the 14th century in England that candle-making became important enough to be regulated by the formation of Guilds. Tallow candles and rushlights became very common in England which, being a pastoral community with wool as the staple trade, abounded in mutton fat for rendering into tallow. In Europe, where pasturage was less abundant, but olives, grape seeds and other sources of vegetable oil were more common, the lamp was more in favour. These conditions remained more or less constant up to the end of the 18th century.

In America conditions were even less advanced than in Europe. The Indians had for long supplemented the light of fires by burning salmonoid fish in Vancouver Island or sucker fish in Maine. The white American settlers collected abundant pinewood (which in 1776 cost 10*s.* to 12*s.* a cartload) or made candles when fat could be spared from their carefully husbanded stores of food. Existence to the settlers was more important than light and in many a hard winter they would have had cause for regret if they had burned too lavishly the fats needed to sustain them before the first spring crops were ready. That was why, in Pennsylvania, seepages of crude oil were sometimes collected for use in lamps where unrefined 'rock oil' was burnt with much smoke and a strong smell. These 'rock oil' lamps would not have seemed unusual to the Sumerians over 4,000 years earlier, except that they might have deplored their rough finish.

The luxury products were the wax candle in Europe, the candle of vegetable tallow in China and the bayberry candle in the settlements along the Atlantic coasts of America where, as recently as 1854, a writer[1]

[1] Dickinson's *Comprehensive Pictures of the Great Exhibition of* 1851. London, 1854.

was able to say of the simple nature of the U.S. exhibits at the Great Exhibition in London:

> 'In the United States it is rare to find wealth so accumulated as to favour the expenditure of large sums upon articles of luxury.'

In those days the bayberry candle was luxurious, but twenty years later a country in which kerosene was found to abound began to overhaul countries that had for so long been ahead.

Light for work, prior to the end of the 18th century, was primitive indeed. The most notable invention was made only at the beginning of the 17th century and that was simply a glass sphere filled with water to concentrate the light from a candle flame upon the work. The lace-makers' condenser, (Plate 3) as it came to be known, was used also by engravers, jewellers, cobblers and others who worked at fine tasks by night, but there were not many of them. Spitalfields weavers, in London, had but a single candle at the loom, for a general rather than a concentrated light was required. The printing press at which Benjamin Franklin worked in London had provision on it for two candles. Kitchen hands, for centuries, worked by the light of pan lamps or candles, while shepherds carried horn lanterns. Clerks and shopkeepers required lights, but extravagance was rare.

The Industrial Revolution beginning about 1750 called for and got a response in terms of improved lighting. Lighting served the needs of the times so admirably that it can safely be said that the history of economic developments would have been very different without it. From 1750 to 1790 there was little change in the lighting available generally, but in 1782–4 the development of the Argand burner (see Chapter III) provided an instrument capable of affecting radically the social scene. For the first time since the lamp came within the competence of man there was a device, under excellent control, that could give ten or twelve times the customary light from a single source. At first, inevitably, the Argand lamp served only the wealthy who could afford the first cost and much greater expenditure of oil just as much as they had been able to afford candelabra and chandeliers indoors or flambeaux outdoors without too great concern about prodigality with wax. Their wealth, however, was becoming more and more dependent on industry which in turn depended greatly on the safe conduct of sea-going and coastwise traffic. The lighthouse as a guide and warning to shipping increased in importance and outgrew the simple candle, oil lamp or coal fire that had sufficed before. The Argand burner soon found its way

into the more important lights round the coasts of Britain, France and America.

Night work in factories was carried on by the crudest forms of light and the exploitation of labour under miserable conditions makes an unpleasant chapter in industrial history. The danger to the plant of fire from naked flames was thought more serious than the inadequacy of the light they provided for the workers. In 1805 the revolutionary new

Fig. 5. The Short-Sighted Man, after a Print by Hogarth

medium, coal gas, was used to light the cotton mills of Henry Lodge, near Halifax. Samuel Clegg and William Murdock lit many mills and factories in the years that followed and the light was relatively good. There were no proper burners and the gas was manufactured under rudimentary methods of control, but although the holes pierced in iron pipes soon corroded round the edges, the light, when moderately well maintained, was at least not as bad as that from candles and pan lamps. The Argand oil burner was too expensive to run for the usual factory and although the Argand principle was soon applied to gas lighting the same considerations of high fuel consumption could not be ignored. Gas lighting, nevertheless, soon appeared in the streets of the principal towns (in London 40,000 gas lamps lit 215 miles of streets by

1823) and for the town dweller at least it made a considerable difference to social life. In houses, where draughts were not severe and management was possible, the oil lamp and candle might not be much worse than gas as an illuminant, but the ability to travel through comparatively well-lit streets from house to house was a very great improvement. Between 1805 and 1860 gas spread rapidly not only into the streets but into houses and factories as well. Even quite small communities, provided they were compact enough, aspired to a local gasworks. For scattered communities the cost of piping for distribution became prohibitive.

The introduction of kerosene (paraffin) on a large scale, beginning about 1869, caused a minor social revolution in the lighting field. The kerosene lamp was simple, reasonably safe, very easy to manage, almost odourless and pleasantly bright. While gas had been a boon to the townsman for many years, kerosene did practically as much for the country dweller at very modest expense. The Pennsylvania oilfields yielded prolifically enough to fill a demand that rocketed as the countryman found himself at last able to compete with the townsman for lighting comfort. Oil in quantity was exported from the United States to Europe and elsewhere and the ubiquitous kerosene lamp provided a light adequate for work or leisure.

The electric filament lamp, which was produced in practical form about twenty years later, made a very slow start compared with gas or kerosene. Many people had produced electric lamps, from 1845 onwards, but none of them were practical until Swan in 1878 and Edison in 1879 both produced lamps that would last for an appreciable time by using the vacuum pump, invented by Sprengel and improved by Crookes to produce a fairly good vacuum within the glass bulb containing the filament. Edison made the greatest individual contribution by virtue of the system of electric distribution that he introduced to go with his lamps. His work on the Pearl Street Power Station, New York City, was not only an expression of his abounding faith in the lamp but from the engineering point of view was impressively advanced in ideas. It was the first power station specifically built with the idea of giving a public electric supply on demand to any consumer, and mains were run beneath the pavements of New York City in all directions. His 3-wire system saved up to 60 per cent of the copper required for such mains and his electrolytic meter enabled him to measure the actual consumption of each customer. By December 1882 he had 203 customers and 3,144 lamps connected in circuit. There were about eighty employees on the pay-roll and 13½ miles of mains. The pioneer

customers had to be satisfied with an average lamp life of perhaps 150 hours, but by early 1884 this had risen to over 400 and by 1886 to over 1,200.

Electric light was not unknown before this, but the carbon arc lamp had many restrictive disadvantages. It was voracious of current and prodigal of light; but the light it gave was harsh and flickering. It had been used on the stage in 1846 and was retained there for special effects, although for street lighting the initial experiments from 1841 onwards were abortive. Great batteries of electro-chemical cells were required to maintain the lights and it was not until 1878–9, when efficient electric

Fig. 6. Work by arc lamps at Kehl bridge across the Rhine.

machines were available, that successful permanent street lighting installations were made in Paris and London. New York City and many other towns in America followed with installations of which the magnitude soon outstripped that of most installations in Europe. Lighthouses had been lit electrically since 1858 when the South Foreland light in the English Channel blazed forth with a 1,500 candle-power source. Even so there were but twelve electrically lit lighthouse lamps in all the world by 1881. Carbon arcs were installed in a number of factories, some warehouses and a few shops. They were used for outside construction work by night and had been used in war. They presaged the great sociological advantages that have been derived from the electric light, but it was the filament lamp rather than the carbon arc that fulfilled the early promise of electricity.

The filament lamp, in spite of the great drive and ingenuity of Edison and the assiduous work of many pioneers in Europe, had what can only

be described as a slow start. Many came to look and marvel, but only a few enthusiasts came to terms. The Edison Company, for instance, had increased its consumer load only from 203 customers and 3,144 lamps to 710 customers and 16,377 lamps in seven years from 1882 to 1888. Ten years later the figures were 9,990 customers and 443,074 lamps, and ten years after that, in 1908, there were nearly 3½ million lamps connected, plus over 54,000 arc lamps for street lighting. Nevertheless it would be difficult to over-praise the pioneering influence of Edison, just as it would be foolish to ignore the contributions of Swan, Sprengel and many other pioneers. The Edison lamp, in New York City, cost the equivalent of paying 186 cents for a thousand cubic feet of gas in 1884 when the actual price of gas was only 138 cents. In places like Salt Lake City gas was about four dollars per thousand cubic feet at this time so that electricity eventually made more rapid strides in the West.

By the time the filament lamp had become of undeniable significance the advent of the incandescent mantle burner for gas lamps had restored the balance between electricity and gas. It was about 1890 that the gas mantle began to forge ahead and it soon caught up with and outstripped the electric lamp competitor. The gas mains and distribution pipes were not only already there, but gas cookers and gas fires were cheaper to run than their electrical counterparts. There was much more incentive to convert Sugg burners to gas mantles than to undertake the great expense of laying on an electric supply for filament lamps that were neither efficient nor long-lasting by modern standards. It was, in fact, not until about 1913 that the filament lamp began to show advantages so demonstrable that in many cases the installation of the necessary wiring was amply worth while. The rest of the story is a question, largely, of reductions in the price of electricity and the price of electric lamps. Gas lighting was admirable in many ways and devices were invented to make the control of it at least comparable with the trouble-free control of electric lights. Nevertheless it had disadvantages domestically, such as the dirtying of ceilings and excessive heating from which electric lamps did not suffer, and for public installations it was obvious that only by rearguard action could it maintain any sort of hold. Just as Edison's lamps infiltrated into a field ostensibly more economically served by gas, so in Britain there have recently been artificial adjustments of the economy of electric-power prices as between town and country that have theoretically restored the economic position of gas in some cases. In spite of that there is no flight from electricity for lighting and this in itself is sufficient indication that the public have selected electric lighting on merit.

There are so many references to the use of electric lighting in following chapters that any attempt to cover the social significance of recent developments in a preliminary chapter would be superfluous. It is, however, permissible to suggest that the cinema depends absolutely on electric lighting as also does television. The theatre would be a shadow of itself without it. The best alternative for the motor-car is acetylene, the carbide for which could only be produced electrically. Gas-lit streets are not necessarily gloomy, but they cannot compare with the evenly-lit electric highway. Flood-lighting by gas is a pale counterfeit of electric irradiation. There is hardly a modern activity in which electric lighting does not play a part. The best illustration of its social significance is given by pondering upon what life would be like without it. Work at night would not be as impossible as it was a hundred years ago if quality were a criterion, but it would still be difficult. Leisure at night would be greatly restricted. Travel at night would be at least less comfortable. The simple evaluation is that all is better for better light, and this is probably correct in spite of those who may deplore a possible decline in reading as compared with viewing; a possible decline in character formation by mitigation of the struggle against adverse conditions, although this may be counterbalanced partly by the advantage to the masses of potentially easier advancement. Like all social problems it is a question of evaluation. Like all social problems it is a matter upon which argument may be never-ending and so, in the chapters that follow, an attempt has been made to present the case without, perhaps, resolving it.

CHAPTER II

Light for the Home (1)

IN summer Darby retired as soon as he had downed his quart of ale. In winter he would be neither so tired nor so ready for bed. Eight hours' sleep has usually been regarded as reasonable, although 16th-century Thomas Tusser would not allow so much. Writing in 1571 he said:

> 'In winter at nine, and in summer at ten
> To bed after supper, both maidens and men.
> In winter at 5 o'clock servant arise,
> In summer at 4 is ever good guise.'

For those who wanted to keep awake in the dark hours there was the fire; or a smoking lamp; a candle that might smoke or gutter; or a torch that would sputter and flare while emitting smoke that resolved itself into flecks of sticky, black matter to foul clothing or furnishings. It was not much of a choice. The rich man commanded the best and employed servants for the messy business of priming the lamps or making the candles, or clearing up the dirt in the mornings. The rich man's candle of bleached white wax was less smelly and burned more clearly than the poor man's tallow, but the light from a single candle was never good. Similarly with lamps the rich man might burn pure olive oil, but he would have to prise up and trim the wick almost as often as the poor man with his lamp burning grease or the smelly oils from fish, and he might not get any more light out of it.

Nobody can tell when man first found, or lost and found again, the art of making fire. Legend tells how Prometheus stole fire from the Gods, and as with his Norse equivalent Loki, suffered terrible punishments for his sacrilege. The early Phoenician historian Sanchoniatho was said in the transcriptions of Eusebius to have ascribed to Phlox, the son of Genus, the discovery of fire by friction. It was described as the second major discovery of ancient man, the earliest being the

finding, by Aeon, of food growing on trees. The building of huts; the use of skins for clothing; the construction of rafts for sea-going and even hunting and fishing were all believed to have been later developments. All this is legendary, but it does point to the importance of fire, the first illuminant, that lit the cave-man home. It was not as an illuminant, even then, that it was chiefly important. For warmth, for cooking, and for scaring away the beasts of the night it was probably held in much higher esteem.

The transition from legend and tradition to recorded history was not simple. Over 4,000 years ago in Britain the neolithic flint miners of Sussex left blackened places on the roofs of their longer mine galleries to show where hollow chalk lamps had stood. At least seven thousand years ago, in Egypt, there was a civilization advanced enough to have weights and measures, but they left no records other than archaeological finds. Fifteen thousand years ago, in the Dordogne, there were men of the later palaeolithic period capable of making the virile and sometimes sophisticated paintings of animals that adorn the Lascaux caves (Plate 3). They used lamps made from hollow stones. To light them they must have been able to control fire. Lamps have also been found in caves at La Mouthe and Trois Frères, while torch marks on the walls and charred fragments on the floor were noted at Altamira in nearby Spain. The Abbé Breuil has suggested 40,000 years ago for the beginnings of cave art; but 40,000 years is not a very long time in the evolutionary history of man. It is, however, very great compared with the short time during which historical events have been written down. Oakley, from archaeological reasoning (see *Antiquity*, No. 118, June 1956), places the earliest fire-makers at 350,000 years ago in China, 250,000 years ago in Europe, and 50,000–100,000 years ago in Africa and West Asia. A great deal of conjectural writing has been done on the origins of fire and light but conjecture is not history. We simply don't know how and when illumination became the servant of man. We can guess that it was not so controlled a servant at first, but the numbers of stone-age lamps and sea-shell lamps that have cropped up in excavations all over the world indicate that it must have been under fair control many thousands of years ago. Moreover there must have been either very careful preservation of fire or a good working knowledge of how to make it.

There are many people in the world today who are still at the stone-age stage of development. Simple things often last for great periods. The poorer native of India—that is a large proportion of the population—is at subsistence level with no furniture, few possessions and

a miserable hovel for a house. Many have to sleep on the pavements. It is therefore quite understandable that what little these people do possess should be of the simplest. The stone-age lamp, the shell lamp and the earthenware saucer lamp are all good, simple designs. In India they survive next door to the latest technical achievements so it is not surprising that in remoter parts of the world they are also to be found. They have turned up in archaeological excavations in every continent, but they are also still in use. The Argand lamp, less than two centuries old, was the only substantially better device from the illuminating point of view. It required a quantity of oil that the poor could not afford and manufacturing resources that the primitive had not got. Of simpler lamps there were improvements in materials and decoration that made them aesthetically more attractive to those that could afford them. There were also a few simple alterations in shape that made it easier to manage them.

The period next to the later stone age from which evidence of lighting methods has come down to us was about 3,000 B.C. when shallow earthenware saucer lamps in the Middle-East and at Nal in Baluchistan were formed with four pinches in the rim to carry wicks. Excavations at Harappa and at Mohenjo-Daro[1] into the site of the early civilization in the Indus valley of about 2,750-2,500 B.C. revealed a few specimens to show that, for instance hanging lamps were made in pottery, and an awkward turn in the stairs was illuminated by a lamp set in a niche. At the palace of Amber, near Jaipur, exactly the same device was used to light the turns in the passage from the kitchens in the 17th and 18th centuries A.D. Projecting bricks in the Mohenjo-Daro walls had a hollowed upper surface and were either used as lamps themselves or as lamp stands. It was, however, from Sir Leonard Wooley's excavations at Ur of the Chaldees in Sumeria[2] that more striking finds were made. Here, buried in the tomb of the Kings (which he dated about 2,600 B.C.) were found lamps in alabaster and gold of which excellent examples are displayed in the British Museum. Others are in the Louvre in Paris. These lamps were not just the simple saucer types. They had long, narrow channels in which lay the wicks. One great significance of this development was that the flame was virtually outside the lamp itself so that it could illuminate downwards as well as upwards. This development no doubt derived from the use of conch shells as lamps as these provided a natural wick channel, but from their unstable shape, were necessarily hung. The lamps of the

[1] *Mohenjo-Daro*, by E. J. H. Mackay. Govt. of India Press, Delhi, 1938.
[2] *Ur Excavations*: Sir Leonard Wooley, Oxford 1934, and other works.

Sumerian Kings in gold and alabaster (the latter were very close to sea-shell shape) were probably more for ritual purposes than for domestic illumination, but the sea-shell lamps on which they were based may well have been quite common as the Persian Gulf, now so far away, was in those days very much closer. The deposition of river silt and the drying out of the marshes provided the reason for the progressive occupation of this new and fertile land region as the sea receded many thousands of years ago, and has been going on ever since.

In the Louvre there is a copper lamp about 4 inches high from base to dish, the dish being about 3 inches diameter, with a lip for the wick, which was found in the 3rd–4th Dynasty Tomb of Izi of Egypt. This would date approximately to the same century as the Royal Tomb of Ur, and shows that Egypt, which very early in history developed trade with the Lebanon, Syria, and not improbably Sumeria as well, had a parallel development in lighting. The seven-branched lamp of the Jews mentioned in Exodus, is difficult to date. A large number of seven-wick lamps has been found in excavations of a Canaanite temple of Astarte found near Acre and dating to 1750–1550 B.C.

There are many other archaeological sites from which evidence of lamp designs has been found but the object of this work is to indicate the usage of light rather than to catalogue the vast variety of shapes that lamps have assumed. It is, therefore, perhaps to Athens that we should go for the next indications. The jump is one of 2,000 years, so we may pause to mention firstly that cups with a built-in oil lamp beneath to warm the liquid were known to the people inhabiting the area near Troy about 1,500 B.C. and secondly that Homer, in the *Odyssey* of about 800, B.C., records how:

> 'Three lamps were placed to light the gloomy courts
> Nourished with dry materials round about
> That they might clearly shine and not go out
> Which damsels snuft and with fresh fewel fed.'[1]

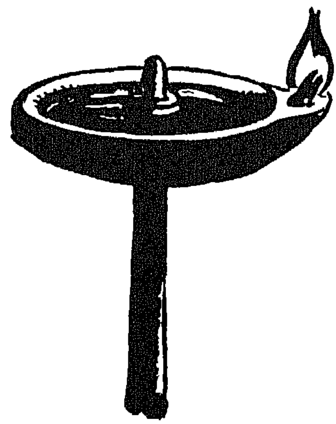
This is one of the earliest written records of domestic illumination, as distinct from inferential information derived from archaeological research. The same method of lighting by dry wood is still to be found in Spain where iron fire baskets on tall stands are used to burn pine splints or needles.

The American School of Classical Studies in Athens has done patient research over many years, the results of which are recorded in

[1] Homer, *Odyssey*, Book XVII, Ogilvy's translation, 1669.

their journal *Hesperia*. They have found fragments of over 10,000 lamps dating between the 3rd and 5th centuries B.C. A visit to the stores of material excavated at the Agora, the old market-place and civic centre of Athens, gives a remarkable proof of the extent to which lamps must have been used. Domestic lighting was probably commonplace to the Greeks, but in Graeco-Roman times lamps became simpler, more numerous and often of very great size.

Fig. 7. Development of the Greek Lamp 600–400 B.C.



Lamp for setting on a spiked stand.

The Romans made pottery lamps in vast quantities and set up factories not only at home but also in their empire. A remote territory such as Britain had several such. In packing a kiln small lamps could be fired between larger pots, thus making better use of the firing space available. The Romans also made hanging lamps in bronze and many of their designs were multi-wicked. The wicks were of oakum or Carpasian flax, but there is a belief that the lamps of the Vestal Virgins had wicks of asbestos.[2]

The better-class Roman house must have been lit by a great number of lamps, and from remains found it appears that the forts housing the soldiery were also lamp-lit on a fair scale. One Roman writer

[1] An expensive material that may have been cotton.

[2] An exhaustive study of perpetually burning lamps was published in 1621 by F. Licetus in his *De Lucernis*. He deduced the use of asbestos wicks from the writings of Pliny and others. In 1684 Dr. Robert Plot of Oxford suggested the use of wicks of asbestos or metallic wire for 'perpetual lamps' in the proceedings of the Royal Society, London: *Phil. Trans.*, 1684, p. 806.

(Ulpien) recorded that it was not necessary for a Provincial Governor to find lodgings for any soldier so poor that he could afford only a single spout as light. Tests on a single-spouted Roman lamp indicated as

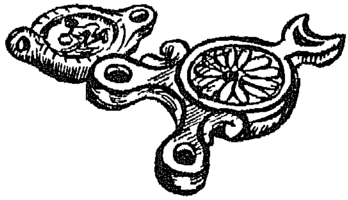


Fig. 8. Roman Pottery Lamps.

much as 50 hours' light for a pint of oil which would hardly seem to make two or more wicks a very great extravagance. Even with the lamp burning at its highest, consumption was only 1 pint in 37 hours.

However, both Juvenal and Aristophanes described how they made use of single spout lamps for the sake of economy.

Some of the Roman candelabra, from which festoons of lamps might be hung, were very elaborate and very expensive. Pliny records the cost of one such at 50,000 sesterces (about £500, or $1,500). One surviving example, in bronze, carried four multi-wicked lamps. What is certain is that all these lamps generated smoke, to some extent, particularly if the oil used were not of the best and in draughty rooms

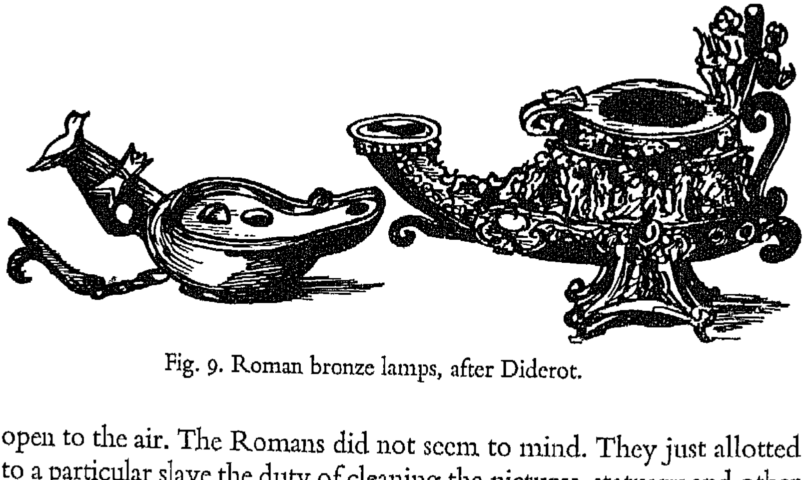
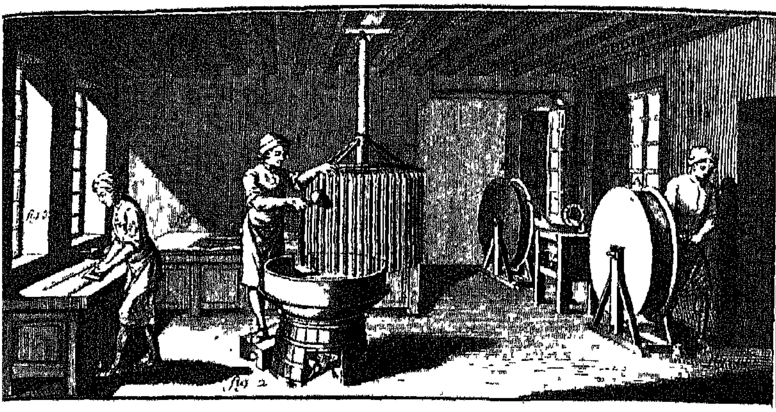


Fig. 9. Roman bronze lamps, after Diderot.

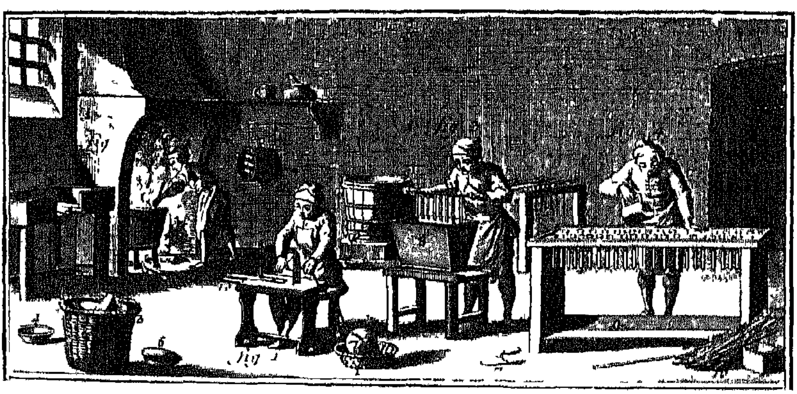
open to the air. The Romans did not seem to mind. They just allotted to a particular slave the duty of cleaning the pictures, statuary and other furnishings in the mornings. To make matters worse they had a

A Lace school, early 19th century
An exhibit in the Science Museum

An impression of cave painting using stone lamps



Making wax candles (Diderot) Rolling, pouring, the long taper



Making tallow candles (Diderot) Melting, wick twisting, dipping, casting

mystical aversion to extinguishing a flame. The dying period of an ill-tended lamp consuming the last of its oil and smoking abominably was just accepted. Even in recent times this difficulty was not unknown. An elderly gentleman who has catalogued collections at Buckingham Palace and Windsor Castle recalls that an old retainer of the royal family in England described to him long ago the stench remaining in Queen Victoria's day after the many hundreds of candles (which took a full hour to light up) had been extinguished rapidly and left to smoke by the servants after one of the evening functions. In *Pantagruel*, Bk. IV, Ch. 26, Rabelais remarks that a torch or candle offers its help and brilliance to all, but the moment it is out it poisons the air with its smoke and smell to the discomfort and displeasure of everybody nearby. The Roman slaves and peasants in their own homes used 'lychnicus' lamps made by setting snail shells, as the oil receptacle, in clay. Such lamps, in great numbers, have been used for local festivals in Italy up to modern times.

Vitruvius, in Book 7, Chapter 3, remarked that there should be no carved work or mouldings in rooms where fire was made or many lights burned. Cornices of intricate design would so quickly get sooted up and require frequent cleaning that plain ones were preferable.

So far consideration has been given mainly to lamps, but the Romans also had the candle. There is in the British Museum an Etruscan bronze object of the 5th century B.C. that looks as though it may have been either a socket candlestick or possibly just a socket into which the stub on the bottom of an earthenware lamp might be set. There is also some ground for belief that ceremonial torches of wax and resin were not unknown at the time of the New Kingdom dynasty in Egypt. The first positive evidence of the candle, however, dates only to the 1st century A.D. when Pliny the Younger described candles made from threads of flax coated with pitch and also rushlights made from rush stems peeled on one side and dipped in wax. At the Portus of Trajan there were whole warehouses, the '*Norrea candelaria*' devoted to torches, candles and tallow. The candle was regarded as inferior to the lamp at this time. Martial (A.D. 40–102) said:

'*Hic tibi nocturnos praestabit cereus igno subducta est peuro namque lucerno tuo*' (Aphph., 42)

a rough translation of which would be: 'I'm sorry the footman has walked off with your lamp—you'll have to put up with a candle.' A stub of Roman candle unearthed at Vaison in France had a wick impregnated with sulphur. This may have been to keep it burning in

draughty rooms, or it may have been to get a light from tinder. In the second century A.D. Apuleius described 'Cerii' made of wax and 'Lebacii' made of tallow. He recorded how 'at a noise in the night the household runs with torches, lamps, tallow candles and wax tapers'.

The Romans used to bleach their wax for candle-making in the hot sun, but it was not until the 5th century A.D. that bleached wax candles were introduced into Byzantium, reputedly by Constantine the Great. There is the usual scarcity of reliable information about the succeeding, poorly documented centuries. A fleeting reference is made by Asser, the Chronicler, to King Alfred's (849–901) time-keeping candles in England. These were made of beeswax and six of them, to burn 24 hours, weighed as much as 72 pence. The reference is to silver pence and a modern candle built to this rough specification and weighing two-fifths of an ounce did burn on trial for just about four hours. How far candles were used domestically is quite unknown. It is much more likely that the fire, and the torches held by torchbearers at special functions, were sufficient for most occasions. The black smeeches poured into the air by burning torches of pitch pine had a stickiness all their own and must have ruined furnishings and clothing in a very short time.

Torchbearers were at one time a common feature at banquets and festivities and it is not at all improbable that they were also used by Lords of the Manor on day-to-day occasions not thought worthy of record. One of the difficulties in trying to evaluate the normal usages of illuminants is that the ordinary was taken for granted and seldom if ever recorded. There was one record of a terrible catastrophe at the Court of Charles VI of France in 1394. According to Montfaucon's 18th-century history of France the Duke of Orleans was one of the torchbearers at a revel in which the principals were disguised as savages. In an attempt to assassinate the King he set a torch to the costume of tow and feathers worn by one of the aristocratic performers. Four knights died in the ensuing conflagration, but the King, who was supposed to be among them, had not participated, so the Duke's plot went astray. The '*Bal des Ardens*' has usually been held to have led to the subsequent insanity of the King, but the truth is that the final stage was nearly twenty years later. Nevertheless, the danger from the use of the unmanageable flames of torches was such that the Duke was confident that the disaster would be regarded as an accident. In 1664 Louis XIV, in one of the functions at Versailles, had 200 footmen with torches to light the reception. These, however, were torches

of the flambeau type and not the cruder and less controllable pine wood.

Another medieval lighting device, derived from Rome, was the cresset; a strap iron holder in which some sort of fire was kept up. The Romans slung cressets for signalling from the top of their watch-towers; and from early days they have been used for fishing. Although primarily outdoor devices they were not unknown domestically. The fire might be anything; pine splits, pine needles, tar-soaked oakum, blubber or almost anything burnable. Small cressets were carried at pole-ends in the streets and are clearly shown in the 14th century Byzantine frescoes. They did not have to be in iron baskets. Gower, in 1350, referred to:

> 'A pot of earth, in which he hath
> A light brennyng in a cresset.'

The Romans had torch-shaped earthenware pots for holding in the hand or setting in a ring at the top of a torch stave. The cresset burning at a stave-top is clearly illustrated on Trajan's column, which dates it to at least the 1st–2nd century A.D. A cresset was a raised fire. It cannot be narrowed down by definition to anything very specific and there are still parts of the world where it is in use.

In the English Chronicle of 1154 there occurs:

> 'Me lihtede candles to oeten by'

and in the 13th century an anonymous writer said:

> 'Al longe nigt songs and candle light.'

The second quotation suggests that the use of candles to such an extent was somewhat prodigal although the tallow candle seems to have been fairly common in England about the end of the 12th century. Although they were for some centuries less common in France, the tallow candle makers had a craft guild in Paris in 1260. This suggests a considerable use of this illuminant although there were less than 100 workers in the trade which they plied by going from house to house making candles out of the fat saved in the kitchens.

Clarified mutton fat was the favoured medium and the Cistercian monks in England very early improved the primitive breeds of sheep known at the time of the Norman Conquest. By the time of the Tudors, English sheep were of many famous breeds renowned in various ways. There were for several centuries great flocks, sometimes over 1,000 strong, all over the country providing the wool for Britain's staple

trade, and at the same time mutton for food and tallow for candles. It was forbidden to have a flock greater than 2,400 but the accuracy of the sheep census from which taxes were raised was questionable in the extreme.

The tallow candle must have become fairly common, even in humble homes, in wool-rearing England. It is impossible to raise wool without, at the same time, growing meat; so the English yeoman lived on a diet of meat that was the envy of the French peasant, to whom soup from old bones and meat perhaps once a month was the normal fare. Similarly with candles, the great flocks of sheep must have provided tallow enough. Animal husbandry was very much a localized affair. If fodder could not be grown and stored, there was nothing to fall back on. Early fodder crops such as lucerne and turnip-rooted cabbage introduced in the 18th century, saved millions of sheep. Before that there was necessarily great slaughter and salting of meat in the autumn; if the spring fodder crop were late even the relatively few half-starved animals that were sparingly fed through the winter months might well die of starvation before they could be saved on the new season's growth. There would not be much tallow to be got from these, but every autumn the flocks were ruthlessly thinned. Thomas Tusser referred to this in his *Calendar* of 1571. For November he said:

> 'At Hallontide, slaughter-time entereth in
> And then doth the husbandman's feasting begin
> From thence unto Shrovetide kill now and then some
> Their offal for household the better will come.'

In his *Good Housewives Day* Tusser refers to the tallow candles under the heading 'Dusk':

> 'Wife make thine own candle
> Provide for thy tallow ere frost cometh in
> And make thine own candle ere winter begin.'

The making of wax candles was regulated in France by an ordinance of Philippe the Beautiful, in 1312. The Worshipful Company of Wax Chandlers in London was founded in 1358 and chartered in 1483. The London Tallow Chandlers Company was founded in the reign of Henry VI (1422–1461) but was incorporated by Edward IV in 1462, over twenty years before the Wax Chandlers (Plates 4*a* and *b*).

The wax candle, although much dearer than that of tallow, was preferred if it could be afforded and was obligatory for church services. In the 17th century candles were made containing ingredients such as

musk so that they would exude perfume as they burned. They were not common, but in this they resumed a practice of the Romans who used perfumes in their lamps at festival times. At the Court of Louis XIV of France no candle was ever re-lighted and the ladies-in-waiting made quite a good thing out of selling, as their perquisite, the candle ends of expensive wax. This seems to have been the custom in other royal households, including those of the Hanoverians in Britain. It seems clear that wax was virtually out of reach of the poorer homes but tallow, fairly common among the less well-off, was also shared with the rich who only exceptionally burned wax all the time.

Any candles were better for frequent attention and the term 'not fit to hold a candle' to anyone derives from the fact that important personages would actually require some servant to hold a candle and tend it when they wanted light. Marguerite d'Angouleme describes it thus in the 15th-century *Heptameron*:

> '*et sourvent, quand le seigneur et la damoiselle etoient couchez, prenoit chascun d'eulx quelque livre de passetemps pour lire en son lict, et leurs chambrières tenoient la chandelle, c'est assavoir la jeune au sieur et l'autre a la demoiselle.*'

At the Court of Louis XIV of France (1643–1715) it was a sign of great favour to be chosen to hold the candle when the king knelt at prayers each night.

A small table to bear a candelabrum, became known as a queridon. This derives from the 17th century round dances in France when one of the number had to stand holding a torch or candle while the dancers chanted:

> '*O queridon des queridons, don, daine!*
> *O queridon des queridons, don, don!*'

When the table replaced the candle holder it acquired its title from the dance. The smoke and dirt from an untended candle could be so bad that in the 16th century in France the expression 'like a wooden chandelier' was used to denote extreme filth.

On the Continent the oil lamp was perhaps more favoured than in England; probably a matter decided by the comparative availability of indigenous materials. In really hot climates, of course, the ordinary candle softened to the point of impossibility. There were no improvements to record in oil lamps over the designs of classical times, and even a measure of retrogression. Roman lamps with 1, 2, 3 or even 4 spouts were as good as any that followed while few medieval lamps

could match the artistry of some of the ancient Greek examples in marble or porphyry. Christian lamps at first were quite plain earthenware of Roman design, perhaps embellished with geometrical patterns, but later bronze types carrying the PX sign have been found in fair numbers (and faked on a much larger scale). Peasants and bondmen continued to use the simplest lamps, including the snail-shell 'lychnicus', up to recent times.

For candles the holders became increasingly elaborate as the centuries passed; 12th-century brass candlesticks were not uncommonly found

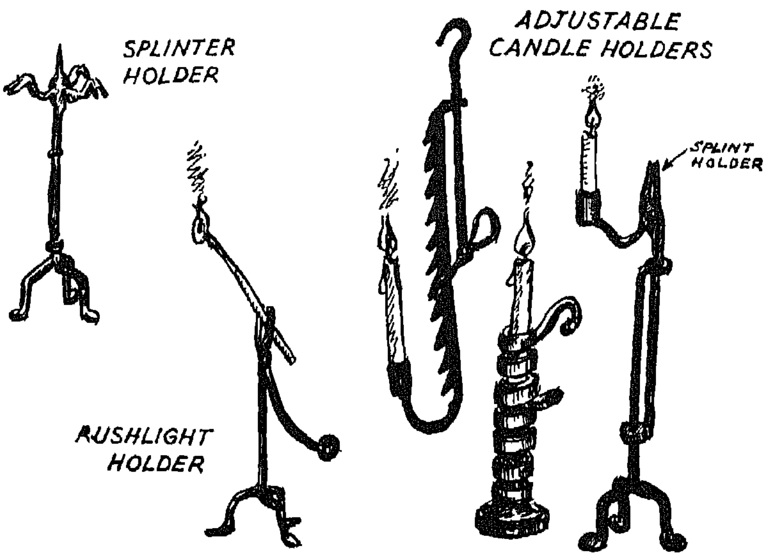


Fig. 10. Adjustable holders.

in the form of animals. In the next century, following the Gothic trend in building, designs became taller and more graceful. Enamelled candlesticks reflected the development of the enameller's art at Limoges in the 13th to 16th centuries. In the 16th century flat candles of very large girth were made for setting on the table during a banquet.

Most candlesticks were of the spike or pricket design, but candle sockets were not unknown in the 13th century despite the later attribution of this invention to Charlotte d'Albret in 1514. Sockets seem so much more sensible than spikes to us, but that is because we are used to candles of hard paraffin wax. Beeswax candles, made by pouring, were relatively soft and were so variable in thickness that it was easier to impale them than to pare down a base too thick for a socket or pack

out a base too thin. Such candles were rolled on a flat table to an approximately constant batch size but neither sockets nor candles were ever truly standardized.

Candles are said to have been made in moulds by Sieur de Brez in the late 15th century. There is, in a private collection, a wooden candle mould dated 1578 in ivory figures. Only the finest and hardest tallow could be moulded, as wax and inferior tallows were too sticky. Mould candles were therefore not so very much less expensive than wax, although a very cheap and inferior product could be made by moulding in sand. Nevertheless, in 1710, candle moulds were described

Fig. 11. Girl filling oil lamp, *from 17th century painting of the Italian school.*

with the copper and the furnace as the implements of the candle-maker's trade in an Act of Parliament imposing taxes on the use of candles in Britain. Wax candles were always made by pouring.

Candles had one unavoidable feature that was overcome by the use of special devices. As the candle burned away the position of the source of light altered. Adjustable holders were therefore made consisting of ratchets, spirals, or even plain rods up and down which the socket

could be moved. Some oil lamps, particularly of English, Dutch and Swiss origin, were also made adjustable in height along a central pillar, but in the case of oil, there was no need for further adjustment once the initally convenient setting had been made.

Two inventions of the 16th century for the improvement of oil lamps received little notice until the closing years of the 18th century. Leonardo da Vinci noted that a metal tube hung above the flame improved aeration, but chimneys only came in with the Argand lamp of 1782–5. Another device, the 'bird-fountain' feed, kept the oil always at the same effective level in the reservoir so that there was a more even flow to the flame. This was discovered by Carden as an improvement of an idea nearly 2,000 years old attributed to Hero of Alexandria, but it was 're-invented' by Miles in 1781. The slowness with which ideas for the better management of oil lamps were applied is difficult to explain for there is no doubt that the average lamp was quite a messy thing to have about the house. It is particularly surprising in view of the fact that a gravity feed lamp (not as controllable as the bird fountain but a distinct refinement on the simple lamp depending on capillary movement of oil up the wick to the flame) was described as early as Zechariah 4. 2:

"And I said I have seen, and behold, a candlestick all of gold with its bowl upon the top of it, and its seven lamps thereon; there are seven pipes to each of the lamps which are upon the top thereof; and two olive trees by it, one upon the right side of the bowl and the other upon the left side thereof . . . what be these two olive branches, which are beside the two golden spouts, that empty the golden oil out of themselves?'

The two great difficulties in the management of oil lamps were oil starvation, leading to thin, smoky flames, and excess of oil leading to robust, smoky flames and overspill. The gravity-fed lamp tended more to excess than starvation, but even the simplest lamp prone to starvation could also run to excess if the reservoir was over full and the wick not exactly matched to the oil supply. Clearly as the oil burned away these conditions might change until the level became low enough to lead to the opposite effect. Even with the lamp extinguished a cold wick might still draw oil by capillary action; the dripping of oil from lamps is a very old problem for which one solution is at least 2,500 years old. There is a small Egyptian lamp in the British Museum in which the base is extended to provide a shallow saucer-like depression below the wick to catch any overflow. Another solution was the

crusie or double pan lamp in which virtually a duplicate of the oil lamp pan is hung immediately below it as a drip catcher. The single crusie dates at least to the 15th century, but the double pan lamp followed probably about two centuries later. Earthenware (as distinct

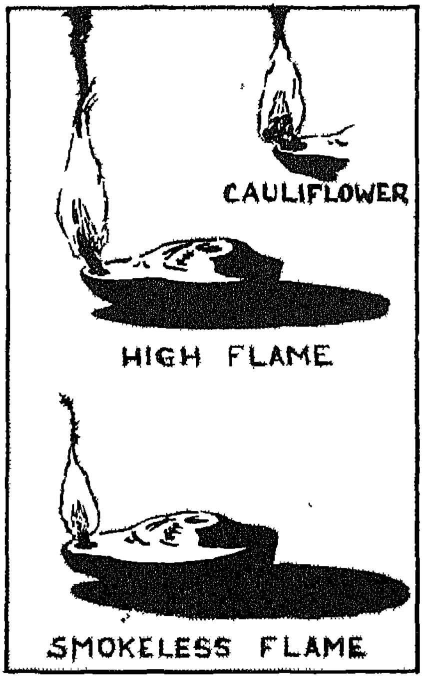


Fig. 12. The Roman Lamp.

from porcelain) lamps were to a small extent pervious to oil, leaving dirty marks where they rested.

The wicks of oil lamps were originally twists of fibre, but in the 18th century cotton gained in favour, just as it did for candle wicks. Cotton or linen rag was often dipped into grease and then singed after being twisted up into a compact wick. Making of wicks was one of the accepted duties of the domestic servant. Rags may have been available in the richer households but in the days of hand-spinning and handloom production they cannot have been in good supply elsewhere. They were also in demand for paper-making. It is reasonable to assume, therefore, that the twisted fibre remained the commonest form of wick for a long time.

The light most easily afforded by the poor was the rush dipped in tallow. Rushlights were known to the Romans and the making of

them became a cottage craft of which there is little early record. Their manufacture, with some thoughts on the economies of their use, was described by Gilbert White in *The Natural History of Selborne*, published in 1789. After telling how women, children and old men gathered rushes he went on to say that 'the proper species of rush for this purpose seems to be the common soft rush found in moist pastures. These are in the best condition in the height of the summer. As soon as they are cut they must be flung into water and kept there for otherwise they will dry and shrink and the peel will not run'. Then comes the rather skilled operation of peeling so as to leave one narrow, even rib from top to bottom that may support the pith. The rushes are then bleached, dried and dipped into scalding fat or grease. 'The careful wife of an industrious Hampshire labourer obtains all her fat for nothing, for she saves the scummings of her bacon pot for this use.' Sixteen hundred rushes went to a pound, and they required 6 lb. of tallow. Thus, each rushlight made to Gilbert White's prescription weighed one fifteenth of an ounce. He went on to say:

"A good rush which measured in length two feet four inches and an half, being minuted, burned only three minutes short of an hour; and a rush of still greater length has been known to burn one hour and a quarter. These rushes give a good clear light. An experienced old housekeeper assures me that 1½ lb. of rushes, completely supplies his family all the year round, since working people burn no candle in the long days, because they rise and go to bed by day-light.'

After remarking that 'little farmers use rushes much in the short days, both morning and evening, in the dairy and kitchen' he described with some feeling how the poor preferred the candle, which made them 'the very worst economists', for a candle costing a halfpenny might not burn more than two hours in the 'blowing open rooms' of the very poor, while eleven rushes with at least half an hour's light in each could be bought for a farthing. The rushlight dropped a line of molten tallow as it burned away and it had to be watched lest it should fall out of its holder towards the end of its short burning time. Nevertheless the tallow candle, for all its greater cost, required just as much attention even if it did not present quite such a problem in drip-catching.

A scientific test of the extent to which a tallow candle lost brilliance if unattended was reported in *The Penny Mechanic*, Vol. III, p. 50, 1838:

'Count Rumford, in his experiments on the comparative brilliancy of different lights, states that he found an ordinary tallow candle,

burning at its greatest brilliancy, gave a light equal to 100; in 11 minutes afterwards it was but 39; in 19 minutes, 23; in 29 minutes, 16. Upon being re-snuffed it regained its former brilliancy of 100. A good wax candle properly snuffed, consumed 100 parts by weight, a tallow candle do. 101; a tallow candle very dim for want of snuffing, 229.'

Thus the untended tallow candle not only gave a mere seventh of the light after half an hour, but in doing so it actually burned more than twice as quickly. These results may be compared with some recently obtained by Prices Patent Candle Company, Limited, in check tests at my request on some tallow candles that used to be exported to the West Indies and West Africa (where they were used principally for cosmetic purposes rather than for light). They contained 10 per cent of soft paraffin wax but this should not seriously affect their performance which was to give 76 per cent of the initial candle power after 5 minutes, 53 per cent after 25 minutes and a rise to 84 per cent five minutes later. The fact is that tallow candles were very variable indeed and much of their variability depended on random considerations quite apart from the initial quality of the tallow which was the greatest single factor. Lamps, rushlights and wax candles were by comparison almost constant in light output as they burned away.

The provision of mirrors and facets from which reflections of candle flames might shine was one way of adding sparkle to a dimly-lit room. In India the Moghul emperors had whole rooms decorated in looking-glass mosaic. A particularly good example dating to the early 18th century is demonstrated to visitors to the palace at Amber, near Jaipur. The effect, with only a couple of candles, is that of a firmament of twinkling stars. The crystal chandelier, so common in the better houses of the 18th century, is perhaps the most abiding impression, in popular imagination, of what contemporary lighting was like. In the Escurial of Madrid there is a record of a crystal chandelier as early as the 16th century; and in later years the making of these ornamental fixtures became an extensive and flourishing industry calling for expert glassworkers and considerable skill in fabrication in metals. All the same it should be realized that they were expensive enough to be the exception rather than the rule and the number of lights they carried also represented an expense that could not be borne as a regular thing in most households. They were common enough in the public places frequented by society, and for special occasions (Plate 17*b*). When they were in use these old rooms, with masses of candles alight in chandeliers and sconces, may have looked pretty enough, but they had their

disadvantages. One wax candle was said to consume as much oxygen as two men, and in addition each candle flame added considerably to the heat of the room. Every ten human bodies radiated an additional heat equivalent, as we would say today, to a one-kilowatt electric fire. A hundred or more guests in a room lit and heated by a hundred candles would not take long to overheat and vitiate the atmosphere.

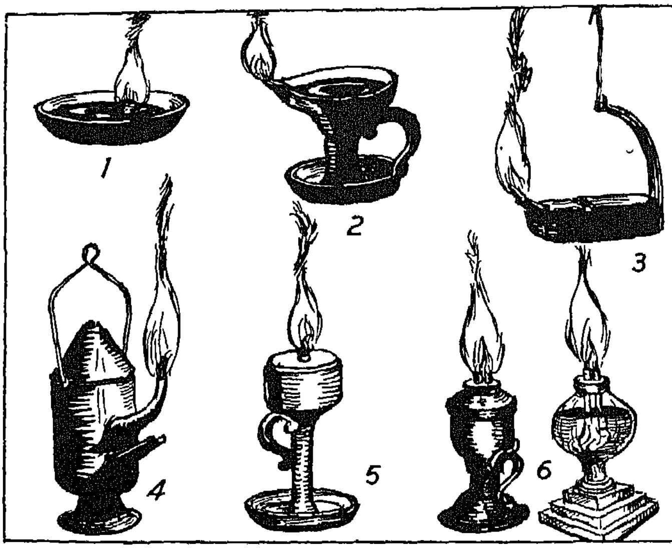


Fig. 13. Early lamps from U.S.A. sources in the U.S. National Museum.
1. Mid-West frontier (Iowa) with a sycamore ball as wick.
2. Pottery lamp, English style, Virginia.
3. Pennsylvania Dutch, 'Cruisie'.
4. Kyal lamp, Cape Cod, *c.* 1820.
5. Pennsylvania grease lamp.
6. Twin tube lamps invented by Benjamin Franklin.

Prodigality with light was exceptional, but the English Colonies that later became the United States of America were even less prodigal than the careful Europeans. In Virginia the better-class families burned fat or heart pine, known as lightwood, in a pan stuck into the side of the kitchen fireplace. Governor Winthrop described its use instead of candles in 1662. They also used long, coiled tapers known, appropriately, as 'pull-ups'. Candlesticks with vertical and horizontal spike legs so that they could be stuck into barn walls or the timbers of a ship's hold were also common in New England. During the Civil War the sockets of bayonets were found to be of the right calibre for candles and there are records that they were used as spike candlesticks. A very

common adjustable candlestick in America was simply a straight iron tube with a slide inside, resting on a large diameter dished base. The base proved admirable for cutting out cookies and even, it was said, for scraping hogs. Crystal chandeliers were almost unknown.

The heat of lamp or candle was not always a disadvantage. In modern times the very poor have frequently rejected the opportunity of change from gas to electric light on account of the degree of warmth obtainable from gas. Marmontel (1723–1799) describing '*Les Fêtes de Noël en Auvergne*' relates that in the evening '*durant le travail, quand nos doigts engourdis de froid ne pouraient plus tenir la plume, la flamme de la lampe ectait le seul foyer ou nous pouvions les degourdir*'.[1] Despite such cases of frozen fingers the naked flame about the house was, in the main, a nuisance. The danger of fire was ever-present. In the great English houses of the 18th century a 'groom of the chamber' went round after prayers to see that all the servants were in bed and that their candles were extinguished. Statistical records of the extent of the danger have been found in *The Mechanics' Magazine* from 1836 onwards. Although the date is late, the danger was old, and presumably earlier ages had much the same experiences, as is evident from the 1st century A.D. writing of Martial (*Epigrams,* XIV, 6) about the relatively safe horn lantern: 'Guide of your way am I carried, a lantern golden with fenced flame, and safe in my bosom is a small light.' Out of 471 London fires in 1835 the causes of 380 were established; 36 were due to various accidents with candles and a further 74 to burning of bed curtains (52) or window curtains (22) mostly from the same cause. In 1836 Wm. Baddeley, writing to *The Mechanics' Magazine,* observed that:

'The most frightful source of accident, however, still continues to originate in the mismanagement of candles, especially in the vicinity of curtains. . . . Placing a candle near to either bed or window curtains is a most improper practice; for, although the distance may be five or six inches, or even more, yet the opening of a door, the moving about of individuals, or a sudden gust of wind, may bring the curtains in contact with the flames, and if prompt assistance be not at hand, may involve the premises in ruin. Mr. Dudley, in the *TOCSIN* very justly observes, "Fifty years ago, all bed-furniture, curtains and c. were made of substantial stuffs; our forefathers would have laughed to scorn the idea of sleeping shrouded with chintz and gauze, and a twinkling

[1] For work, when our frozen fingers could scarcely grasp the pen, the flame of the lamp was the only means of thawing them out.

gaslight, floating in a glass tumbler, which even a poor fly, with the vibrations of its wings, will extinguish."'

'The fact is that no *unguarded* light should ever be permitted in any stable, warehouse, cellar, or bed chamber; cheap, convenient, or even elegant handlamps and lanterns suited to these uses are met with in abundance. It is an important fact that no instance of fire from the use of enclosed lights, has been met with among all the calamities of the last few years. Neglect of this precaution, however, caused the destruction of thirty buildings in Charter-house-square alone last year. Open, exposed lamps, have occasioned serious accidents, for they are not a

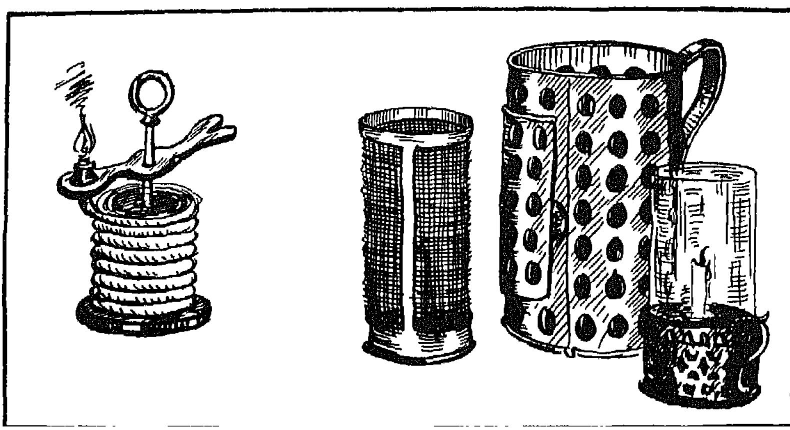


Fig. 14. 'Pull-up'. Candle Guards and night light.

whit better than candles; but enclosed within glass walls, the light is greatly improved, and the chance of accident incomparably small.'

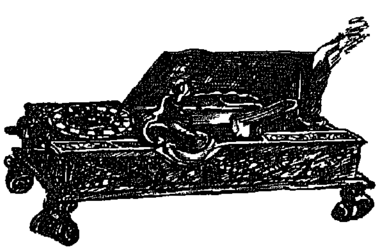
The precautions continued to be neglected, for in the following year, 157 fires from the same causes were recorded out of 468 for which the origins were ascertainable. By 1848 the number of fires from ascertainable causes had risen to 767, of which 237 were due to candles, and ignited curtains. A new category of danger was also becoming significant at that time, for 39 fires were due to the escape of gas from defective fittings; 7 from accidents in lighting the gas; 15 from leaving the gas too high; and 4 others due to gas, making 65 in all. In the same year only three fires were caused by oil lamps.

One of the ways in which the risk of fire might be minimized was by the use of candle guards made of wire or sheet metal, often with a pool of water in the base so that if the candle burned down completely

it would be extinquished before it could do any harm. Some of these guards, of pierced iron, served also as windshields so that the candle might not be extinguished in a draughty corridor or if a door or window should be opened.

The night light, to enable the sleeper to see if he should wish to get up during the hours of darkness, took many forms. It might be a small oil lamp, or a stubby, slow-burning wax candle either set in a saucer of water or later, with a non-inflammable plaster of paris base so that it would not set fire to anything if it burnt right out. In Regency and Victorian times special glass shades for night-lights were sold. One brand of light made by Prices of Battersea, was curiously named 'The Burglar's Horror'. In 1882 fifty million night-lights of various kinds were consumed annually in Britain.

The danger of fire from bed curtains still remained, and in 1828 *The Mechanics' Magazine* made a curious suggestion for an improved night-light. A phial of clear white glass, of long form, is one-third filled with boiling oil poured over a piece of phosphorus the size of a pea. A cork is removed to let in air periodically over a period of six months during which the device 'will give as much light as a dull, ordinary lamp . . . during the night to admit of the hour being easily told on the dial of a watch'. This device is less ingenious than one made by Joseph Tich of Vienna a century earlier, to be seen in the Science Museum, London. An alarm-clock sets off a charge of gunpowder which ignites a piece of tinder which springs into view, already alight, when it is time for the owner to get up.



CHAPTER III

Light for the Home (II)

FROM THE ARGAND LAMP TO MODERN TIMES

THE first revolutionary developments in lamp design since prehistoric times may be claimed, if lighting power is to be the criterion, by Ami Argand of Geneva, who was born of upper middle-class parents in 1759. Before his time there had been improvements in the shapes and convenience of lamps, but virtually no increase in their capacity to illuminate. Suddenly in 1782–4, there came a tenfold increase in the light obtainable from a single wick. Naturally the whole of this impressive increase was not obtainable without an increase in the amount of oil consumed, but the cost was much less than proportionate while, in certain circumstances, the result was greatly to be desired. Not, it may be said, in all circumstances. Later in this chapter figures of comparative light outputs will be quoted. Where a candle was good enough, an Argand lamp became an extravagance; where economic circumstances precluded extravagance, the Argand lamp became an impossibility.

Argand had an interesting history. He was first sent to study physical science under the professorship of a famous man, Henri Benedict de Sassure. In his own right as a physicist de Sassure was well known, but to Alpinists his name is enshrined among those of the great pioneers. He was the one who offered a prize, in 1761, to the first man to climb Mont Blanc. It was not won until 1786, when Dr. Paccard with Jacques Balmat as guide, succeeded in reaching the summit. In the next year, 1787, de Sassure got there himself. A decade or so earlier he had recommended his pupil Argand to Lavoisier, the famous chemist.

In 1780, after a short stay under the academic guidance of Lavoisier, Argand was recommended to the vintners of Languedoc who required an adviser on an improved process of distillation. It was in this capacity that he devised his first tubular-wick lamp which was sufficiently bright

to impress the members of the Senate of Languedoc. The flat ribbon wick of cotton appears to have been introduced by Leger in 1773. Argand bent his cotton wicks into a tubular form so that air could also be drawn up through the centre to assist the peripheral currents in the achievement of complete combustion. There was no glass chimney, at first, to help aeration by creating an upward draught of air under conditions of greater control, but even so the results were so encouraging that he arranged to accompany his friends the Montgolfier brothers of Annonay on their visit to Paris, in 1783.

The Montgolfiers had launched a hot-air balloon containing a cock, a duck and a sheep, at Annonay in 1783, and they were called to Paris for demonstrations that resulted, on November 17th, in the first free aerial ascent by man. The Marquis d'Arlandes and Pilâtre de Rozier travelled across Paris for nearly five miles at an altitude of about 300 feet in a Montgolfier hot-air balloon. Popular excitement was tremendous and when a physicist, M. Charles, and one of the two brothers Robert who had made a balloon for him, made an impressive journey in a hydrogen balloon on December 1st of the same year, excitement became almost unbounded. A mere lamp, whatever its success, could not compete for popular attention and although Argand showed it to de Vaux and Lesage at the French Academy of Sciences, where it was estimated to be the equivalent of ten or twelve candles, its real significance was virtually submerged beneath the greater excitements provided by the aeronauts. 'You will observe, Madam, that the balloon engages all mankind,' wrote Dr. Johnson to Mrs. Thrale.

Argand persisted, however. He conceived the idea of adding a glass chimney and he realized that the tougher flint glass would be preferable. He seems to have had difficulty in finding either backers or manufacturing capacity in Paris, and in 1784 he was in London, where his efforts met with more success. Meanwhile, in Paris, his ideas had not gone unnoticed.

The story is an odd one. Mr. Quinquet, a pharmacist, seems to have got hold of every bit of information he could about Argand's lamp, and even to have heard about his glass chimney idea. As an entrepreneur he was far ahead of the possibly more scientifically and socially preoccupied Argand; he made contact with Mr. Lange, a distiller to the King, who also had a business in oil and a tinsmith's establishment, and between them they started the manufacture on a fair scale. This was about 1785.

Later Quinquet and Lange quarrelled. Lange joined forces with

Argand himself and made a significant contribution to the efficiency of the lamps. He realized that a constriction in the diameter of the chimney at just about the height of the flame would increase air turbulence and aid combustion. There is some evidence that this was but a resurrection of a design known a decade before, but to Lange should go considerable credit. In England, where they were made in 1784, the lamps were always called after their true inventor, Argand; in France they seem invariably to have been called Quinquets after the entrepreneur who did not contribute even so much as Lange and seems remarkable only for the speed with which he filched Argand's ideas. The business acumen of the erstwhile partner Lange, a very successful man of commerce, may well have been the decisive factor in capturing a market so quickly. Later Quinquet and Lange appear to have become reconciled through the intervention of the same Marquis d'Arlandes, the great friend of the Montgolfiers and of Argand, and one of the first two aeronauts. Argand seems not to have objected to these proceedings and was apparently a man of great forbearance.

Whatever the injustice in the title there can be no doubt that 'Quinquets' very soon found their way into the wealthy homes of France, just as similar 'Argand' lamps were everywhere to be found in the better-class homes in Britain. The Presidential relics of George Washington (1789–99) in the U.S. National Museum include three lamps of the Argand design that must have been among the earliest in America. Argand was credited with the invention of the rack and pinion wick feed whereby a metal tube carrying the wick could be raised up and down with ease. The oil supply to the tubular wicks had to be copious and a common arrangement was to feed it by gravity from a container at a higher level than the top of the wick, a tap in the communicating pipe controlling the supply. Excess oil was caught in a container below the wick, but obviously there were disadvantages in such a hit-and-miss method of control. The advantage of simplicity kept this design alive for long enough, but refinements were quickly forthcoming. In 1798 a little clockwork pump to force oil upwards was immersed in an oil container below the wick, and any excess oil simply flowed back to the reservoir below. These lamps were known as Carcel lamps and the oil used was frequently colza oil which became known as a result of the popularity of these lamps, as Carcel oil. In another type, the 'Moderator' lamp, the oil was pressed up a central tube to the wick by means of a powerful spring-operated piston filling the whole diameter of the oil reservoir. Excess oil in this case flowed back to the top side of the piston in the reservoir

from which it could later be run off and used with fresh oil to replenish the supply. There were many variations on this forced feed principle.

The relatively good light from these lamps was not obtained without a relatively high expenditure of oil. They were also expensive initially so that their application was largely confined to shops, public places and the better homes. One gentlemen writing to *The Mechanics' Magazine* remarked that after straining dirty oil through flannel he found it would not burn in his Carcel lamp; so he sent it out to

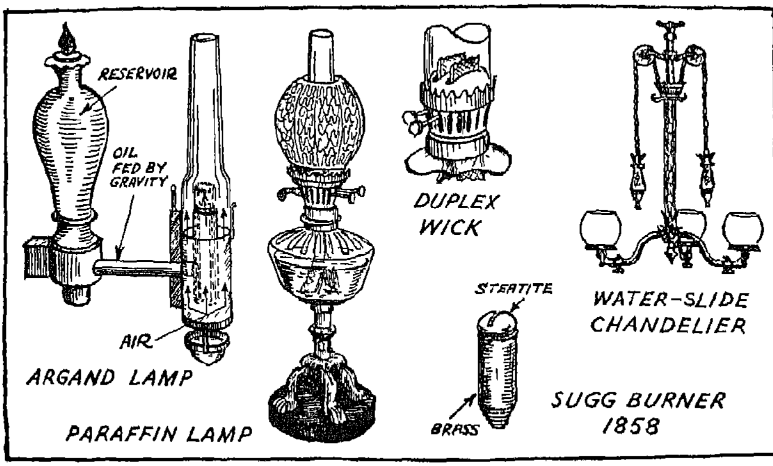


Fig. 15. Argand, paraffin lamps, etc.

the servants and found it would not burn in their open pan lamps either.

In great houses such as Chatsworth, the seat of the Dukes of Devonshire, pairs of Argands, with a single reservoir to each pair, were arranged as sconces around the wall. The merchants and bankers of the City of London presented two enormous candelabra to the Duke of Wellington, each consisting of a cluster of Argands with a central reservoir above. They were not without disadvantages. It was no simple task immediately after turning out the lamp to handle a hot and fragile chimney if the wick required trimming; and if the wick were not trimmed, when it required it, an uneven flame, too high at one place, might easily crack the chimney anyway. It was not easy to trim the wick accurately with scissors so that it presented a perfectly even cylinder above the oil channel. Devices were invented to make

the process easy, but their useful life was short. Theoretically the wicks were trimmed during the daytime and at night all that was required was occasionally to turn them up a trifle. In practice a badly-trimmed wick rapidly deteriorated and even a well-trimmed wick might for a variety of reasons begin to burn unevenly. It by no means followed that a lamp trimmed in the daytime would last the night without trouble.

The Argand burner did not achieve the universality that was later to be the measure of success attending the paraffin lamp. The demand for candles continued to rise, and as so often happens, the price, quality and convenience of candles showed spectacular improvements, particularly between 1820 and 1840. At this time the air was full of the marvels of gas lighting. So excited were the populace at a new lighting medium 'more congenial to the lungs than oxygen' and absolutely non-explosive, that they contributed heavily to the National Light and Heat Company of which Winser, the inventor of little other than these fictitious qualities of coal gas, was the founder. His original scheme was for 20,000 shares of £50 nominal value of which £5 had to be paid on application. The balance was to be paid out of an estimated profit of £570 per share per annum. Less than a century after the South Sea Bubble the citizens of London were again duped by promises of something they desired but could not understand. It so happened that for several decades gas remained very much less than an ideal medium and supplies proved expensive and limited. At 15*s.* per thousand cubic feet it was out of reach for most people and the vast majority of homes could expect no quick change from oil and candles. The London *Sunday Times*, on April 23rd, 1854, claimed that 'filthy tallow candles and stinking oil lamps have been nearly rendered obsolete by the introduction of gas, and we look to the abolition of smoky chimneys and all the inconveniences of coal fires in our parlours by a very ingenious gas stove patented by Messrs. Smith and Phillips'. A century later the smoky chimneys are still not abolished, but the lights of most civilized communities are greatly improved.

The Argand principle was also applied to gas burners and one of the frequent statistical exercises of the early 19th century was to try to evaluate, usually with doubtful scientific authority, the cost of light from various sources. The calculations usually took the Argand as standard 'and the others to give the same light'. *The Mechanics' Magazine* in 1823 gave the following figures, to which have been added those (not per hour) from *The Penny Mechanic* of 1838.

Type of Illumination	*Mech. Mag.*	*Penny Mech.*
Argand burner, coal gas	$\frac{3}{4}$*d.* per hr.	2$\frac{3}{4}$d.
„ „ sperm oil	1$\frac{3}{4}$*d.* „ „	6*d.*
„ „ seal oil	1*d.* „ „	4*d.*
Tallow candles, 8 to the lb.	1$\frac{1}{2}$*d.* „ „	–
Wax candles „	6*d.* „ „	1*s.*

What is not clear from such table is that 1 lb. of candles, depending on their size, would give 32–60 hours of light, burned singly. The Argand burner could not economically give the light of a single candle; just as a multiplicity of candles could not compete economically with one Argand burner. There was room for both, each in its proper sphere, and both survived what competition there was between them. In the home it was the paraffin lamps of the 1860s rather than the Argand burner that presented the greatest threat to the candle as an illuminant.

Candles improved out of all recognition between 1820 and 1840. Firstly there was the discovery by Cambacères, in 1820, that plaiting instead of twisting the cotton wicks resulted in a 'snuffless' candle using the new high-melting-point fatty acids, as the wick bent over into the hot outer part of the flame where it was fully consumed. There was at the time scientific research work into the fatty acids, culminating in a classic paper published in France in 1823 by Chevreul on '*Récherches Chimiques sur les corps gras d'origine animale*'. Two years later Gay Lussac introduced stearic acid, and Milly, an Englishman, helped to establish it commercially. In 1831 Milly also impregnated candle wicks with boric acid to eliminate guttering.

Thomas Binns, who described himself in his patent specification of 1801 as a 'water-closet maker', devised a water-cooled mould to simplify candle-making. In 1823 the invention by Joseph Morgan of a movable piston to eject the finished candles made the process easier still. By the time of Queen Victoria's marriage in 1840 excellent 'snuffless' candles could be bought at a shilling a lb. The moulding machine was further improved by Tuck & Palmer between 1842 and 1845 and finally, in 1855, two Americans, Humiston and Stainforth, worked independently to produce machines incorporating all previous improvements and some new ones that resulted in designs little different from that in use today. A little time might still be saved in the actual forming processes by the application at some expense of modern

mechanical techniques, but the finished candles would still have to be left undisturbed for twenty minutes to 'cure', so the saving of a few more seconds is unimportant. The only major mechanical improvement after 1855 was in 1861 when Field devised a machine for those mould candles that were required with conical ends to fit all sizes of socket and thus eliminate the tiresome processes of either shaving the ends to fit, or wedging them with bits of paper if the sockets were too large. Finally, in the 1860s, paraffin wax made both better and cheaper candles; but at the same time paraffin oil made lamps so much better and more competitive than they had been that they were soon to be seen even in the more modest homes. A very limited range of simple candles required in large quantities are today made by a cold extrusion process, but the older techniques are likely to survive indefinitely for economic reasons.

Coal gas, meanwhile, had gradually extended its hold in large towns even though the corrodability of burners and the variability of gas supplies had somewhat cooled the ardour of those who saw in it a panacea for all lighting ills. In the late 1850s a campaign against unpurified gas was led by Dr. Henry Lethely, the Medical Officer of Health for the City of London. Its imperfections were now declaimed almost as persistently as its virtues had formerly been extolled and humorous journals published cartoons showing citizens searching for the gas lights with a candle. One simple invention did much to restore it to favour. In 1858 William Sugg of London invented a burner with a steatite top which neither corroded nor allowed so much heat to escape from the flame (Fig. 15). Another invention of about 1870 was the counter-weighted 'water slide' gasolier, or chandelier which could be pulled down or pushed up at will and soon became immensely popular with those that could afford it. 'Christiana' burners, in which gas consumption was controlled by a regulator were frequently used in these contrivances. The incandescent mantle did not come in until the last decade of the century, by which time both paraffin and electricity were well established.

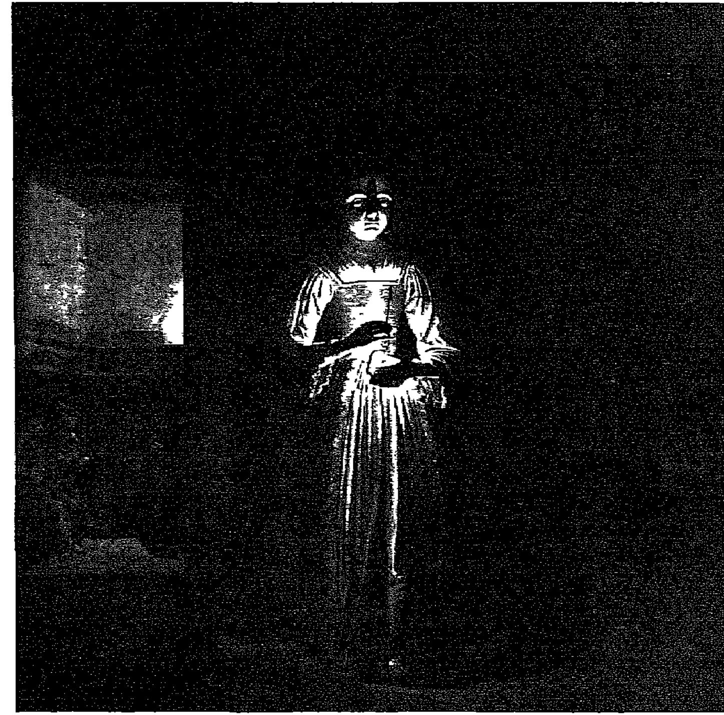
Paraffin (or kerosene as it was known in the early days) was a boon to rich and poor alike. It had been available in small quantities, particularly in Central Europe, nearly ten years before the prolific oil wells of Pennsylvania began to flood the world markets in the early 1860s. In 1859 New York actually imported 10,000 gallons of Burmese oil from London. That was the year in which Colonel Drake found petroleum in commercial quantities in Pennsylvania and a couple of years later the position was completely reversed. Paraffin was the

kind of oil people had dreamed about for centuries, and it was cheaper than any other. The paraffin lamp was relatively clean; the oil was stable; the smell was slight and not unpleasant; the flame was a good colour and practically smokeless; the flat wick was easily trimmed and it lifted the oil to the flame in satisfactory quantities by capillary action alone; a single spurred wheel was the only mechanism required for lifting or lowering the wick itself and thereby controlling the oil supply. When the duplex burner, consisting of two parallel flat wicks about an eighth of an inch apart, giving a brighter flame still, was introduced by Hinks in 1865 it seemed that the paraffin lamp was almost the perfect illuminant. To a world that had but lately rejected the explosive camphine as just a little too dangerous to use in spite of the excellent light it gave, paraffin seemed completely safe. It was, at all events, quite difficult to make it dangerous. By 1879, when the first successful electric lamps were appearing, America was shipping 350 million gallons of oil, additionally to the amounts she consumed internally.

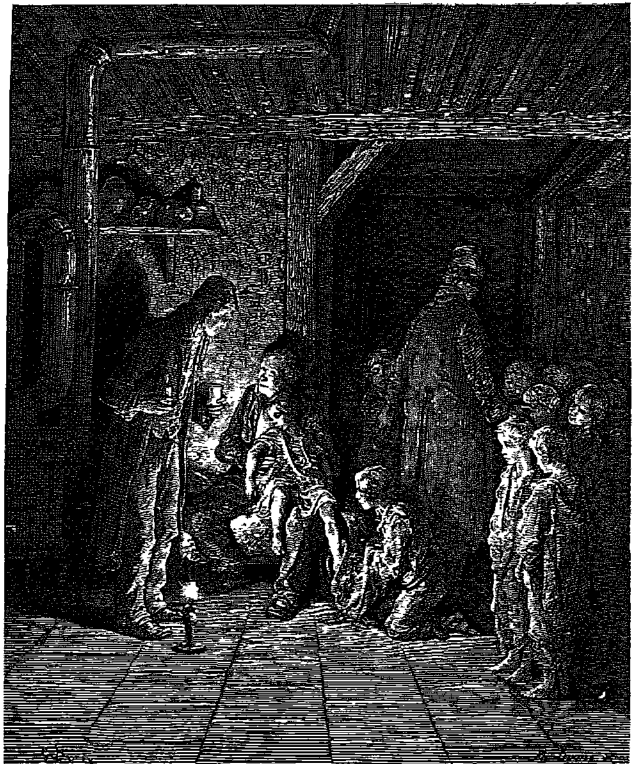
In 1890 a report on lamp accidents was submitted to the Chief Inspector of Explosives in Britain by Boverton Redwood and Sir Frederick Abel. They came to the conclusion that a large proportion of accidents was due to upsetting or dropping lamps. Some were caused by filling up with benzene instead of lamp oil. Others by winding the wick right down into the oil reservoir. Blowing down the chimney to put the flame out might result in an explosion. The wind might in some circumstances do practically the same thing. Most explosions were, however, so slight that they did not even break the reservoir, but many still had dangerous and sometimes fatal consequences. They recommended the lamps should have metal reservoirs, special means for extinguishing, and above all carefully fitting wicks loosely plaited of long staple cotton and just long enough to reach the bottom of the reservoir. Lamps, they said, should be kept thoroughly clean; charred wick and dirt removed and the oil reservoir filled every time before use. The part of the wick in the oil should be enclosed in a tube of thin sheet metal, open at the bottom, or in a cylinder of fine wire gauze. These matters might not in themselves be too arduous, except for the frequent attention to wicks and oil level, but they illustrated the fact that lamps, even after mineral oil came in, still needed management. Illuminating power was soon lost otherwise, apart from possible dangers.

Electricity was for many years the subject of conjecture and experiment, but it was long before it was successful. Arc lamps, demonstrated

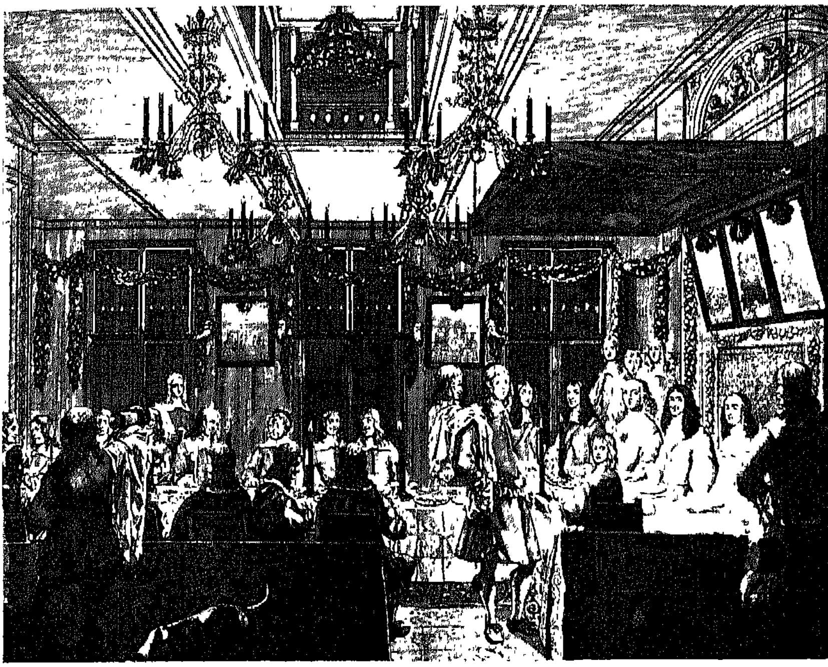
Girl de-lousing (School of Gherardo delle Notte)
Palazzo Doria, Rome



Woman at an Inn (Heimbach)
Palazzo Doria. Rome

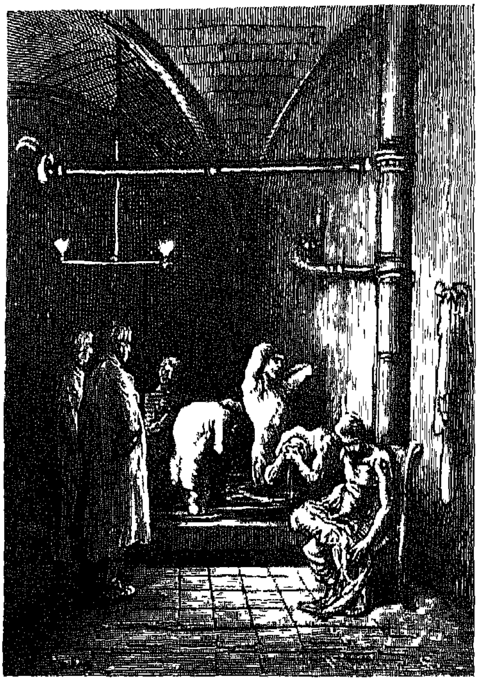

Found on the street, London by Gustav Doré, 1872


Domestic scene, 1616



Farewell dinner to Charles II at the Hague, 1660

Banquet des Dames, Tuleries, 1835 by Viollet le Duc
Musée du Carnavalet, Paris



Bath at night refuge, 1872 by Gustav Doré

Scripture reader in a night refuge, London, 1872 by Gustav Doré

triumphantly by Sir Humphry Davy in 1810 after ten years of experimentation, were clearly inappropriate to the home. Incandescent lamps could not be made to survive longer than a few hours at most, and there were no machines to provide the necessary current anyway. De la Rue was experimenting with glowing filaments about 1820, but no more is known of his results than of the electric light by the light of which James B. Lindsay wrote to the *Dundee Advertiser* in October, 1835. It was some sort of glowing filament as he claimed that he could read a book at a distance of 1½ feet from it. In 1836 he demonstrated it publicly, and although he claimed that 'on its introduction to spinning mills, conflagrations there will be unheard of . . . exposed to the open air it will burn with undiminished lustre amid tempests of wind and rain; and being capable of surpassing all lights in splendour it will be used for lighthouses . . . the present generation may yet have it burning in their houses and enlightening their streets', so little came of it that its inventor remains practically unknown.

When Grove, in 1840, heated a platinum wire to incandescence in the imperfect vacuum obtained by inverting a tumbler over a bowl of water, he had to use wet cells as a source of light. Seven years later W. E. Staite made a similar experiment in Sunderland, using a battery of 44 plates. *The Times* described the resultant light as '*immense,* resembling a spark of the most brilliant and vivid fire', 'resembling a day or sun light and observing the light of candles in the manner that rays of daylight obscure them'. The *Illustrated London News* of October 2nd, 1852, pointed coldly to the economic facts of such experiments:

'Attempts have been made within the last few years to produce light by electricity. For purposes of artificial illumination the cost is so great, that it cannot be used with any chance of profits, or even success.'

Similar attempts were made in America where Professor Farmer, for instance, lit the parlour of his house in Salem, Massachusetts, with incandescent platinum strips in 1859. There were, however, three essential factors without which success could not be achieved. One was the provision of machines able to generate current economically. The Gramme machine of 1870 was encouraging from this point of view. The second was the ability to obtain a vacuum sufficiently good to inhibit the oxidation and therefore destruction of the incandescent filament, while at the same time, by preventing excessive heat losses, enabling the filament to run economically at a temperature giving high incandescence. The Sprengel vacuum pump of 1865 was far superior

to any previously available but even that was not good enough till it had been vastly improved by Sir William Crookes who published an account of his researches in 1875. The third was to find a practical filament material, for the fusing point of platinum was much too close to the temperature at which it became highly incandescent.

Meanwhile a *tour de force* had taken place in St. Petersburg. Lodyguin lit the Admiralty Dockyard in 1872 with 200 lamps containing graphite filaments in an atmosphere of nitrogen. He received a large cash prize from the Academy of Sciences and obtained the favourable comment of the Tsar, but his lamps only lasted for an average of about twelve hours' burning time and his scheme was soon abandoned.

There is little doubt that the credit for the practical introduction of electric lighting in the home must be shared between Swan in England and Edison in America, the Crookes-Sprengel pump being the touchstone. Swan was actually the first, in 1878, but for thirty years he had been experimenting until the vacuum pump of 1875 provided the factor that made success possible. Edison followed in 1879 after only eighteen months or so devoted to experiment, and both his lamps and his ideas of electricity distribution to feed them were more advanced than those of Swan. A quarrel over the dry dust of precedence developed, but happily these two great men composed their differences and, in the Edison-Swan Electric Company in Great Britain, established a monument to their co-operation that is still in existence today. Edison, in 1881-2, had such abounding faith in his invention that he built the Pearl Street Power Station in New York City specifically to provide a public electricity supply for his lamps (Plate 19). Electrical engineers can still marvel at some of the advanced features of this power station which contained ideas that were regarded as revolutionary only a few decades ago. Edison also devised an electricity meter to enable him to charge for the actual current consumed, a method of payment for services that took quite a long time to become universal. Curiously enough, unlike Swan, he did not light his own house electrically. Swan, in 1883, restored the balance between them by inventing the squirted nitro-cellulose filament which proved stronger and more uniform than any other, and was adopted for Edison lamps as well. This invention, quite as a side line, laid the foundations of the great artificial silk industry.

Among many other pioneers Lane-Fox and Sawyer are perhaps most worthy of mention, but the technical stages of lamp development must be looked for elsewhere. It should suffice to say, and to help in acquiring a sense of perspective, that the original lamps of both Swan

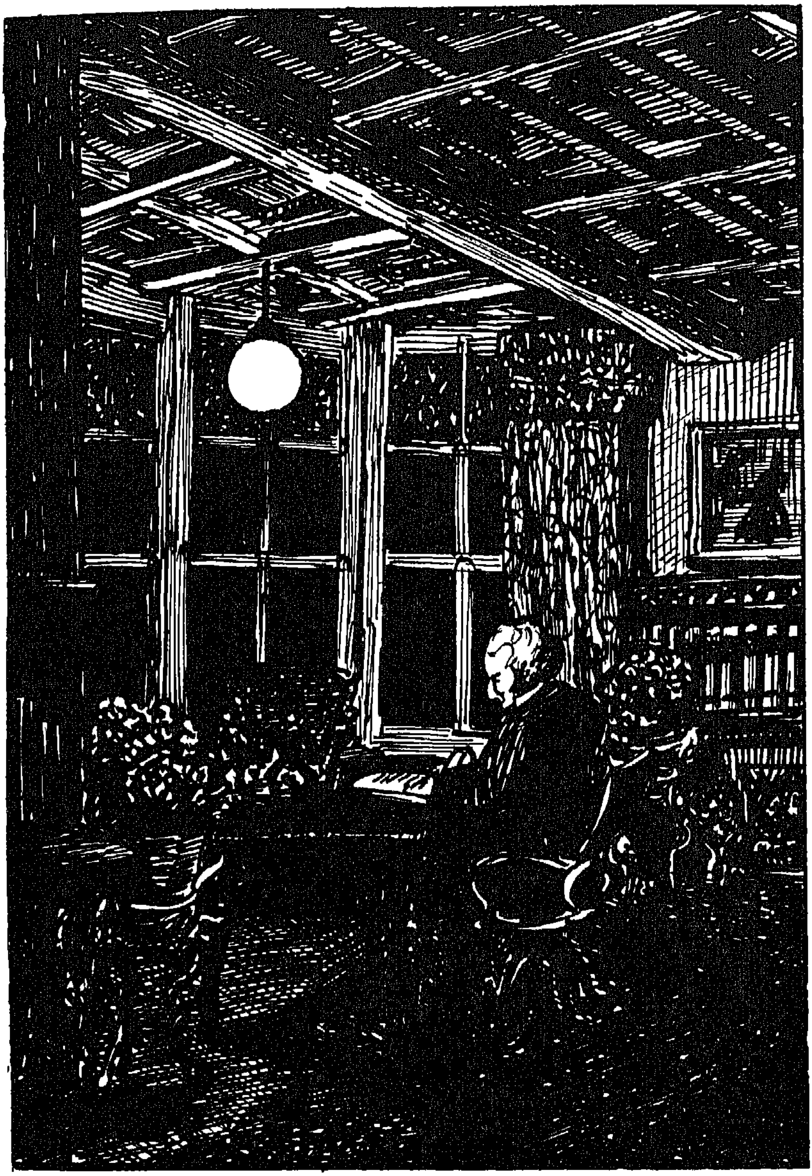


Fig. 16. Swan lamps in Sir W. G. Armstrong's library, 1880.

and Edison were out of date almost before they were effectively on the market. Originally the Swan lamp was priced at 25*s.* and the Edison lamp about a sixth as much. In 1883, when the squirted cellulose filament came in, Swan lamps had dropped to the more competitive

price of 5*s.* and a 60-watt lamp was rated at 20-candle power. The price of electricity at that time varied between 7*d.* and 1*s.* per unit.[1]

In America, following Edison's pioneer Pearl Street installation of 1882, the provision of electric power stations for providing public supplies was very much more rapid than in Britain where at first it was usual for a prospective user to install his own plant and where later developments were crippled by unwise legislation. Sir W. G. Armstrong, whose house was the first to be lit by Swan lamps in

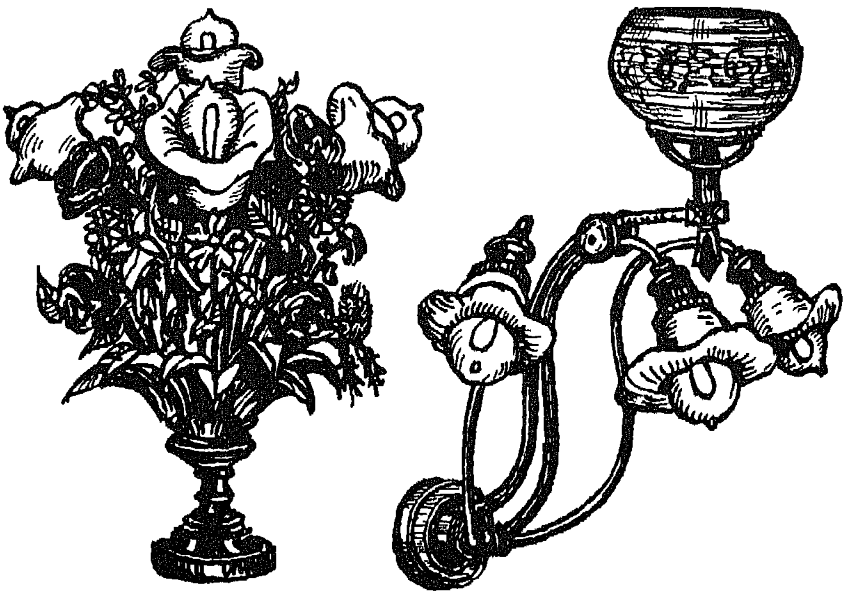


Fig. 17. Epergne. Combined gas and electric.
EDISON FIXTURES, 1883.

Britain, drew 6 horse-power from a water turbine, 1500 yards away from his house. He had 45 lamps in all, 8 of them in the library 33 feet by 20 feet. As many as 20 lamps could be lit in the picture gallery. Most of the lamps were in ground glass globes, but as he wrote in a letter to *The Engineer* of January 17th, 1881:

'In the passages and stairs the lamps are for the most part used without glass shades, and present a very beautiful and star-like appearance, not so bright as to pain the eye in passing, and very efficient for lighting the way.'

[1] In those days 25*s.* were the equivalent of about 6 dollars. One penny equalled two cents; i.e. 7*d.* = 14 cents, 1*s.* = 24 cents.

'Each single lamp is about equal to a duplex kerosene lamp well turned up. . . . Being unattended with combustion and out of contact with the atmosphere it differs from all other lights in having no vitiating effect on the air of a room. In short nothing can be better than this light for domestic use.'

Another pioneer user, Octavius E. Coope, wrote to *The Times* of January 16th, 1883, that by using electricity instead of gas:

'I have no nuisance of lime or of tar, or other refuse products; no leakage of gas into the house, no smell in the manufacture, or damage to my garden; and in the place of an unsightly gasometer, I have a compact little engine, placed out of view, and which, when not driving the dynamos, is utilised for pumping water to the top of the house, and can also be employed for sawing wood, or other purposes.

'Having had 20 years' experience of lighting this house by gas—which I consider a great improvement on any previously known method—I am only too sensible of its drawbacks and, although I am not doing away with it here yet, I am well satisfied that I have adopted electricity.'

It was, however, no ordinary house. His first year's working, with 200 18-candle-power electric lamps, cost him £232 ($1,150).

In the towns, of course, gas supplies came from public gasworks and were easier to give. By slow degrees electric supplies became available too. Gas was by no means finished as a means of lighting in comparison with the more brilliant electric light even though, in 1878, there was a panic fall in the value of gas shares on the London market. The German Welsbach mantle was used, in upright form, in the MacTear Burner introduced in London in 1887 at a price of £1 1*s.* ($5). It was, however, about 1893 before developments of these mantles, both in form and ease of manufacture, made their use commonplace although even then a price of 1*s.* 3*d.* each put them out of reach of many. The gas lamp, in domestic sizes, again became as brilliant as any competitor. The inverted burner also invented in Germany by Ahrend in 1903, was later improved by many succeeding designs. The virtue of the inverted burner was that it did throw most of its light downwards, in the direction in which it was wanted, whereas the upright burner shared the disadvantage of the candle in that the ceiling received more light than the natural working plane below. The difficulty with all incandescent mantle burners was so to regulate the flame that it

exactly filled the envelope of the mantle, for the highest and therefore most efficient temperatures for incandescence were to be encountered at the periphery of combustion. Complete combustion, another important factor, could be regulated by controlling the size of the orifices through which gas and air were admitted respectively. The difference in shape between upright and inverted mantles was accounted for by the necessity for 'flame fitting'.

Even in recent times poorer people have clung to gas lighting for the heat it also gives in winter. To those more fortunate economically this fortuitous characteristic is not necessarily an asset, but to gas companies the pennies of the poor have given important revenue. The

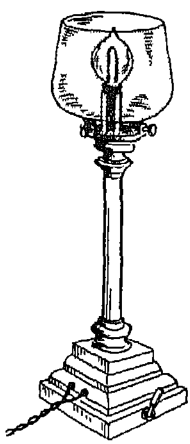


Fig. 18. Swan table lamp, 1881.

penny-in-the-slot gas meter, in 1892, began to take a hold on public imagination after four years without success. The numbers installed in succeeding years were so phenomenal that they were responsible for arresting the decline in demand for gas in London. The price of gas had by then come down to 2*s.* 6*d.* per 1,000 cubic feet, compared with 15*s.* in 1824.

The electric lamp developed slowly during this period while the search continued to find a more satisfactory material than carbon from which to make filaments. The rare earth group of metals seemed to offer advantages, but the difficulty was to draw a wire sufficiently fine and strong that would stand up to both high temperature working and mechanical shocks. In 1897 osmium filament lamps were produced in Germany by Count Auer von Welsbach of gas mantle fame. They were expensive both on account of the cost of the filament and the

hand work required to erect glass supports within the bulb. The Nernst lamp, commercially introduced about 1900, employed filaments of zirconium oxide which required no vacuum for operation. The disadvantages of these lamps were such that after a moderately successful run they seemed to disappear from the market about 1912. The fragility of the filament was one of the most serious difficulties. Tantalum introduced commercially by von Bolton in 1905–6, was better than Osmium in some ways and was less brittle, but it could not be worked as a filament at a high enough temperature for high efficiency. For many years it was used in traction lamps, as it resisted vibration so well that it paid to sacrifice efficiency. Tungsten seemed ideal, but from 1884 to 1909 the search for a means of making it sufficiently ductile proved abortive. Then, in 1909, Coolidge in U.S.A. found how to make it ductile by swaging and sintering. Drawn tungsten wire has been used since 1911 for filament lamps, which were subsequently improved by successive developments in the way the filament was handled.

In 1913 efficiency went up from about 7 to 10 lumens per watt—a rise of over 40 per cent—by coiling the filament and running it in an atmosphere of inert gas. This development again came from U.S.A., Langmuir being responsible. The inert gas was Argon, a rare gas separated in England by Rayleigh, in 1894. In 1934 the filament was again coiled upon itself to give the 'coiled coil' and an efficiency of about 12 lumens per watt. High-powered projector lamps, of 5–10 kilowatt capacity (compared with the $\frac{1}{10}$ kilowatt capacity of the 100-watt lamp) may have an efficiency as high as 24 lumens per watt.

In 1940 the fluorescent tubular lamp, 5 feet long, with an efficiency of about 38 lumens per watt, or about three times the efficiency of the ordinary domestic filament lamp, was introduced in Britain. (It is now very much more efficient.) In America more suitable sizes for domestic uses were quickly forthcoming, but wartime preoccupations with other matters delayed a similar development in Europe. The higher efficiency is not all gain as the lamps require expensive control gear and are themselves not cheap. Technical calculations indicate that they are unlikely to show any great economy over filament lamps unless they are going to be in use for a substantial period each year. Aesthetic considerations and personal prejudices may preclude their use in the home for other reasons. There is still great controversy over fluorescent lighting, but it is not a subject upon which one should be too dogmatic. If the light is to be on for 1,000 hours a year or more it may be more economical in terms of price per lumen, including

installation charges, than filament lighting; the economy becomes greater as the usage in hours increases, but both sodium and mercury discharge lamps, which nobody would think of installing in a dwelling-house, may be more economical still. The fluorescent lamp gives an admirable almost shadow-free light for many applications and the

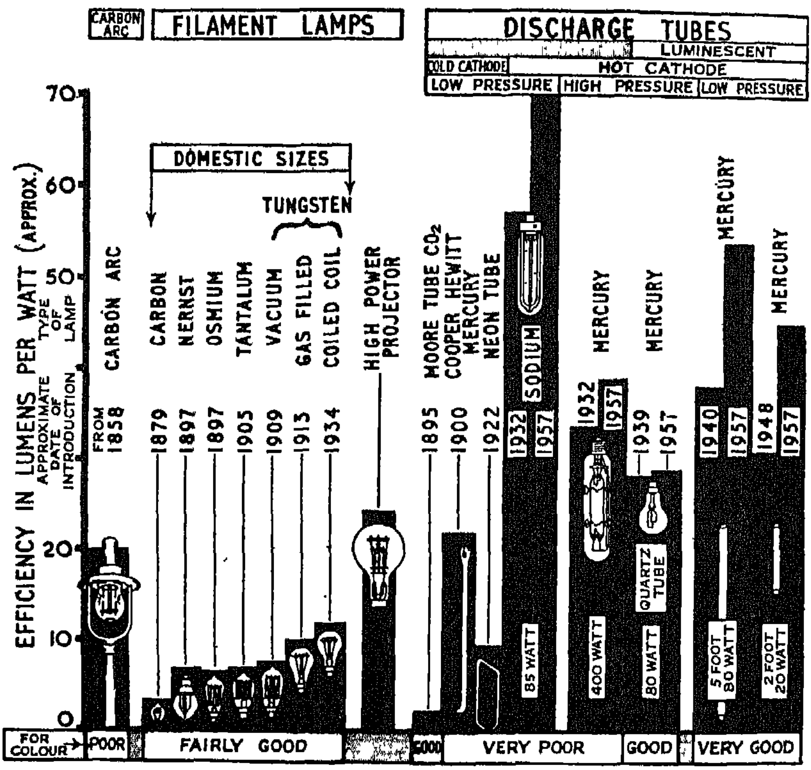


Fig. 19. The rise in efficiency of electric lamps.

source is of a relatively low intensity, thus reducing glare. It may give colour-renderings to which we are not accustomed at night (even though they may be nearer to some daylight renderings[1] than those obtained with filament lamps). It can give such high intensities for

[1] Daylight is not a simply definable matter. Taking noonday sunlight as an arbitrary standard the variation to be found in England is somewhat as follows:

Constituents	Noonday sun	Overcast North Sky	Blue North Sky
Red	100	82	78
Green	100	92	84
Blue	100	119	138

relatively little fuel consumption (say 5 : 1) that colours become more noticeable.

Home lighting is largely a matter of personal preferences and rarely decided by technical considerations alone. Some people are preoccupied with the subject of glare which is frequently diagnosed in a room that is merely bright. Other people suffer eyestrain in the gloom of rooms that would have been bright to our forebears. In the old days some people found candles and oil lamps glaring. The metal plates so often mistaken for reflectors are actually glare shields. A bright room today would seem dull to anyone entering directly from the midday sun outdoors. The dark Jacobean oak room lit in period style today might seem dark to the original owner who panelled it three centuries ago in oak that was at that time light. Modern lighting must be regarded as an instrument that makes possible effects that would have been out of the question only a short time ago. Relative progress has been so great and so fast that no firm tradition has had time to grow. We have made great progress, but even a dim and watery sun should make us feel quite humble about it.

CHAPTER IV

Light for Travel

DURING the 1939–45 war in Britain there was no street lighting of any kind and the windows of houses were darkly shrouded. The results included an awareness of the phases of the moon that had certainly been rare before the war among city dwellers; and everybody carried an electric torch. The torches by modern standards were dim, for the lenses had to be obscured by some dimming and diffusing medium such as paper. The people returned to the conditions of medieval times, with the exception that there was more law and order and little chance of being molested by footpads. When the moon shone, torches were not much use and were frequently left at home. Even a cloudy night with the moon above was bright enough for most obstacles to be avoided, and a moonless night with stars in the sky was almost as good. But a rainy, moonless night was black and impenetrable. If a torch failed, or was forgotten on such occasions, the best remembered road became a perilous adventure. A cross-country journey, unless by compass or over exceptionally well-known country, became impossible, even with a torch, in such weather. The torch was good enough to disclose perils and obstacles, but it required the more pervasive light of nature to distinguish features of the countryside.

This reversion, in modern experience, to old-time conditions makes it easier to appreciate the problems of travel by night in the past and the manner in which they were overcome. The choice of nights when the moon was full for Freemasons' Lodges and other functions becomes easy to understand. So becomes the addiction to the display of phases of the moon as part of the mechanism of grandfather clocks. When, in *The Merchant of Venice* Portia said:

> '*How far that little candle throws his beams*'

her servant, Nerissa, answered:

> 'When the moon shone we did not see the candle,'

a remark that tells its own story.

THE TORCH

While the moon may have been far more useful than any torch to the traveller by night, the fact remains that from very early times torches have had to serve on innumerable occasions. Homer (800 B.C.) mentions the torch of resinous pine which has been used right down to modern times. It was not an ideal kind of torch. As it burned away it dropped globules of molten resin and exuded sticky carbon specks. It gave an illumination that was fitful even if at times brilliant. The resinous matter bound up in a palm or pandamus leaf by South Sea Islanders and other native tribes had similar disadvantages. The 'links' hawked by the link boys in London up to little more than a century ago were twists of rag or ends of rope dipped in pitch, resin or melted candle ends. They can have been no better than the torches of Papuan natives and from Cruikshank's drawing 'After the Opera' of 1821 (Plate 10) their bearers seem hardly more civilised in appearance.

Cruikshank may have exaggerated, for torch-bearing is an ancient calling, and the torch-bearers were supposed to be some protection for the personage by whom they were hired. In *TheMerchant of Venice* the essential quality of their service is well defined:

> 'We will slink away at supper time; and return all in an hour.
> We have not yet made good preparations.
> We have not spoken us yet of torchbearers.'

Propertius (54 B.C.–A.D. 2) tells us that the Romans, who used wax torches, regarded the number of torch ends abandoned outside the house of a lady of more beauty than virtue as a matter for scandal. Propertius recorded this rather sadly for, as he also said, 'scandal has ever been the doom of beauty".

Medieval flambeaux were far superior to the cruder links. The design dates back to the thirteenth-century, at which time iron cressets flaring at the tops of poles were the usual alternatives. In *The Betrayal* painted by Bouts in 1450, flambeaux are shown carried at the top of torch staves, a practice that may date back as far as the New Kingdom in Egypt and was certainly known to the Romans who also carried cressets aloft in the same way. Flambeaux originally had tow wicks

which were impregnated with resin and coated with wax. Later, in the eighteenth-century, cotton wicks were employed. The principle requirement was that they should burn fiercely enough (and therefore extravagantly) to resist wind and rain. A bunch of four wicks gave a cloverleaf section, the grooves being scraped out to provide channels down which excess wax and resin might flow instead of becoming wind-borne. The torch staves were carried upright as steadily as possible. Shakespeare, in Henry V, describes the French Knights somewhat contemptuously in these terms:

> 'The horsemen sit like fixed candlesticks
> With torch staves in their hands.'

Another reference to the everyday importance of the torch to the traveller by night is given by Falstaff's famous description of the red-nosed Bardolph:

> 'O thou art a perpetual triumph, an everlasting bonfire light
> Thou hast saved me a thousand marks in links and torches
> Walking with thee in the night between tavern and tavern; but
> The sack thou hast drunk me would have bought me lights
> As good cheap at the dearest chandlers in Europe.'

There is a flamboyance about the torch, to use a word of obvious derivation, that is absent from the lantern. The light is brighter and more scintillating. It challenges the elements out of its own strength. For occasions of rejoicing, or for honouring achievement it has remained, down the ages, in a position that the lantern has never attained. When, for instance, at 5.30 p.m. on December 2nd, 1783, a cart rumbled into Paris carrying the envelope of the hydrogen balloon in which M. Charles had made a triumphantly successful ascent the day before, it soon received an escort of gentlemen on horseback around whom there came spontaneously a number of citizens bearing torches to dispel the approaching darkness. Seventy years later there was no spontaneity about the torch-light welcome to the members of the Legislative Corps who travelled in a procession of 200 carriages from the Chamber of Deputies in Paris to St. Cloud where they were to proclaim the re-establishment of the French Empire in the presence of the Emperor. A numerous escort of the 7th Lancers on horseback, bearing torches, was lined up along the route so that whether the night was wet or fine there should be no hitch in the proceedings. Perhaps the most flamboyant of all torches is described in a visit by the Abbé Chappe d'Auteroche to Siberia in 1762. The tartars 'set light to fir

trees at proper distances'. These trees 'kindled from bottom to top in a minute', and so lit the way.[1]

On the occasion of the visit of Queen Elizabeth II to Fiji in December, 1953, she and the Duke of Edinburgh 'were escorted by two lines of running torchbearers' . . . 'The silence seemed eerie as some 200 stalwart Fijians, their torches flickering in the breeze, loped barefoot beside the slowly moving motor-cars'.[2] In Ceylon the following April for a traditional royal *perahera*, a procession in which 140 caparision elephants took part, the ceremonies were attended by torch-bearers carrying braziers on long poles, replenished from time to time with copra to feed the bright flames.

THE LANTERN

Lanterns are also of great antiquity. In Psalm 119 there is the line:

> 'The word is a lamp unto my feet
> And light unto my path.'

The horn lantern may have been referred to by Ampedocles in Greece of the 5th Century B.C. He uses the word '*Φαρος*'. It is certainly the meaning in the words of Plautus (251–184 B.C.):

> '*Quo ambulas tu, qui Vulcanum in cornu conclusum geris.*'

At Herculaneum, which was overwhelmed in A.D. 79, a bronze horn lantern has been found. It had a central-wick oil lamp and a cylinder of fabricated horn giving a very unobstructed view of the light from all sides. By the time of Pliny the Elder, whose *Natural History* was written in the 1st century A.D., the working of horn had become an art:

> 'With us horn is cut into transparent plates to give a wider diffusion to a light enclosed in it; and it is also applied to many articles of luxury, sometimes dyed, sometimes painted, sometimes what is called from a certain kind of picture, engraved.'

Horn lanterns may have gone the way of many other developments during the dark ages, for there is a belief, not well authenticated, that King Alfred re-introduced them in Britain in the 9th century. The Horners are at least one of the ancient liveried companies of the City

[1] *The Gentleman's Magazine*, London, Vol. XXXIII, p. 551, 1763.

[2] *The Times*, December 18th, 1953.

of London, 54th in precedence. The making of the leaves was a skilled art, and as there is so little apparent similarity between the horns of a beast and the panes of a lantern it may be worth while to explain the process.

The horns, those of the bull and cow, were macerated in water for 4–6 weeks to putrefy and soften the tough membrane between core and horn. The cores were then extracted, the horn tips sawn off (for making buttons and knife handles) and the hollow part was then softened for half an hour in boiling water. While hot it was held in the

Fig. 20. The smoking lantern, *after a 17th century print by Bocquet.*

flame of a coal or wood fire until it acquired the temperature of molten lead, at which it became very soft indeed. It was then slit with a knife and the edges opened out by special pairs of pincers. The hollow horn thus became a flat sheet which was pressed between heated and greased iron plates. For horn lanterns the pressure was made great enough to 'break the grain'. The individual laminae then separated slightly and were prised apart with a round-pointed knife. The plates were then laid on a board covered with bull's hide, fastened down with a wedge, and scraped with a draw knife having a wire edge. When they had been scraped to the desired thickness they were polished with a woollen rag dipped in charcoal dust, rubbed with rotten stone

and finished off by rubbing with horn shavings. These 'windows' could readily be bent to any shape after exposure to damp air. The longest and thinnest were called 'sensitive Chinese leaves' by the trade in recognition of the Chinese origin of the originals. Several pieces of horn could be fused together by the application of heat by a skilled manipulator, to make a window of large size.

Horn lanterns were very common. In Paris there were enough artisans engaged in their production to justify the formation of a Guild in the 13th century. The carriers, in *King Henry IV*, refused to lend their lanterns to Gadshill, obviously thinking that they might be stolen, and Shakespeare with robust and punning wit makes Falstaff refer to this commonplace article in the same play:

> 'For he hath the horn of abundance, and the lightness of his wife shines through it; and yet cannot he see, though he have his own lantern to light him.'

Early in the 18th century lanterns of tin and horn, 7 inches in diameter by 14 inches high cost £1 10*s*. per dozen. Two centuries earlier the household sizes, which were smaller, cost 4*d*. to 6*d*. each. These prices represent two or three days' pay for the workman.

The London watchmen used horn lanterns as part of their equipment. It was no doubt from such a lantern that Boswell, after an hour's uneasy wait in the dark through snuffing his candle out by accident, had it 're-lumed' in 1763. In 1809 Rowlandson drew a scene in the watch house of St. Mary le Bone (Plate 11). A number of not very impressive figures, the forerunners of the London police, are shown in multi-caped overcoats, bearing staves; each man carries his horn lantern and many more lanterns await collection.

When Mr. Green, the aeronaut, descended in marshy land at Pirbright Common near Guildford in his colossal 'Nassau' balloon in 1852 (Plate 10), he feared disaster for himself and his passengers. If even one had jumped the balloon would have risen again sharply, and anybody else jumping might have had a nasty or even fatal fall from an unexpected height. It was already after dark, so even in so desolate a spot he commanded everyone to stay where they were until they could better assess their chances or get help from the ground. Presently the country folk arrived as if from nowhere, and as shown by the picture of this tricky situation in the *Illustrated London News* of the day, each of the yokels was bearing a horn lantern. Florence Nightingale would have used mostly the folding candle lanterns of the country, like Chinese lanterns. She would certainly have

been most unwise to use the most inappropriate Greco-Roman lamps with which she has commonly been portrayed.

So commonplace were horn lanterns that instances of their use can be multiplied from the literature of many countries. Theophile Gautier, for instance, described in his *Voyage en Espagne* of 1840 his

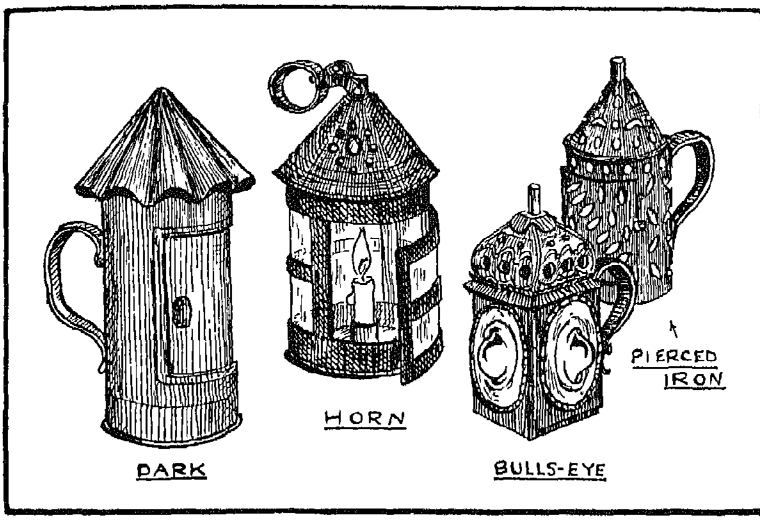


Fig. 21. Lanterns

attempted departure from Toledo at 1 a.m. in order to avoid the worst of the heat on the next day's journey:

Un seréno. . . . marchait devant nous, portant au bout de sa lance une lanterne dont les vacillantes lueurs produisaient toutes sortes de jeux d'ombre et de lumière que Rembrandt n'eut pas dédaigne de placer dans quelques-unes de ses belles eaux-fortes de rondes et de patrouilles de nuit. . . . De temps en temps notre seréno avançait sa lanterne sous le nez de quelque drole endormi en travers de la rue, et le faisait ranger avec le bois de sa lance; car en quelque endroit que le sommeil prenne un Espagnol, il étend son manteau à terre et so couche avec une philosophie et un flegme parfait.'[1]

The next happening was that they were held up for a couple of hours

[1] A watchman . . . walked before us carrying at the end of his lance a lantern from which the flickering rays made tricks of light and shade that would not have been disdained by Rembrandt for portraying in oils the patrols of the night watch. From time to time our watchman held his lantern under the nose of some curious fellow sleeping in the middle of the street, and stirred him with the butt of his lance. For wherever sleep overtakes a Spaniard he just spreads his robe on the ground and goes perfectly content to bed.

at the firmly closed gates of the town. In spite of the lance and lantern of the seréno the Spaniards in general regarded night travel as unworthy of encouragement.

Horn was a good, cheap and pliable material that was virtually non-inflammable. It might be charred, cracked or spoiled if the candle or the lantern were to fall over, but even then it might still remain substantially serviceable. It was at least less vulnerable to rough treatment than glass, and yet the glass-fronted lantern came into demand.

Firstly, before flat glass became cheap and plentiful, there was a limited usage of mica which was imported into England as 'muscovy glass' in the 16th century. From as early as the 13th century luxurious lanterns had been made inset with small ovals of crystal, which would to some extent concentrate a beam, although the main object appears to have been decorative. Early in the 18th century, however, the bull's-eye lantern was frankly utilitarian. The technical limitations of glass manufacture at the time actually made it easier to produce a bull's-eye than a sizeable piece of flat glass. It was not from choice that window-panes were small and often bore the 'bottle' marks that are now regarded as picturesque. Similarly with lamps. The bulls-eye was a necessity that had, fortunately, some virtue. It concentrated a beam of sorts, and to that extent made the lamp a little more efficient at probing into the dark. It also made it easier to blind the person at whom the lamp might be levelled. Many of these bull's-eye lanterns had lenses on three of the four sides, the handle being at the back. The bearer, by holding the lantern at arm's length, could keep all light off himself.

In the 12th century 'coronas' in the cathedrals at Aix-la-Chapelle and Hildesheim, the chimney portions over the candle lanterns were pierced with lozenge-shaped holes. This same 'colander' technique was applied to crude, windproof lanterns found in Southern Germany and Austria from the 15th century onwards and also well known in Colonial America. The light, and not much of it, escaped as best it might, but at least there were a few spots to see by and the wind and rain could be defeated without the expensive refinement of glass or horn.

It was only a step from these inefficient lanterns to the dark lanterns in which no light was allowed to escape at all until the bearer opened a panel that concealed the flame within. Dark lanterns appear to have been equally popular with thieves, who could conceal their presence until the coast was clear, and the guardians of the peace chasing them who hoped to surprise the thieves. The electric dry-battery so admirably

fulfilling the purpose of a dark lantern, was used in quantity by Dock Police of the Port of London Authority only in 1913, and by the Metropolitan Police in London in the following year. As battery-operated hand lamps were being sold by the Electric Contact Co. of New York for some years prior to 1900 it is surprising that they spread so slowly into obviously suitable fields.

The element of surprise by light was not confined to the dark lantern. In Diderot's *Encyclopediaque* of 1765–72 there is a description of the unsporting duellist who conceals a lantern behind his back

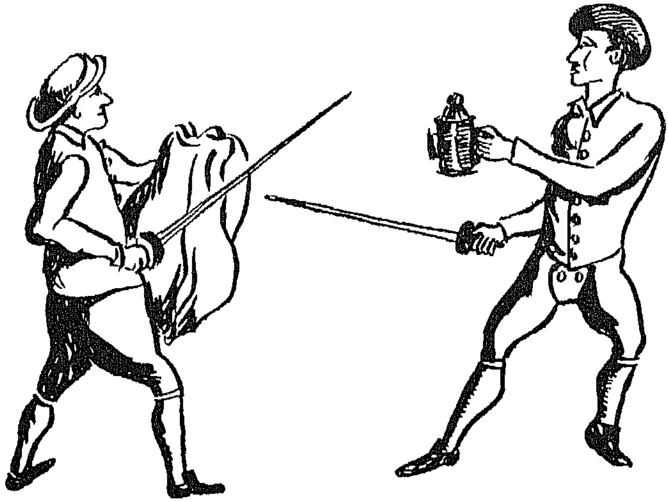


Fig. 22. The unsporting duellist.

and then at a chosen moment produces it to surprise and confound his opponent by its glare. As the source of glare was but a single candle it is to be presumed that for effectiveness the duel must have been arranged at the first glimmerings of daylight before dawn.

In Eastern countries a very distinctive type of lantern was developed. The Chinese and Japanese folding lanterns had sides of paper or silk, while Persian lanterns had sides of translucent cloth. The danger of setting fire to these inflammable materials was obviated in an ancient Korean design in which the candle was carried in gimbals.

Flat glass panes for lanterns became easier to obtain later in the 18th century, but it was not until about 1820 that the lantern within a spherical glass globe achieved some popularity. The popular 'hurricane lamp' that swept away most rivals after kerosene oil came, was not

introduced until the 1870s. The excellence of the design may be gauged from the fact that it is little changed in the roadmenders' lanterns of the present day.

CARRIAGE LAMPS

The directional beam that we expect today from motor-car headlights (or even a hand torch) lights up the way for many yards ahead. The light from early lanterns was very feeble, even though it might be

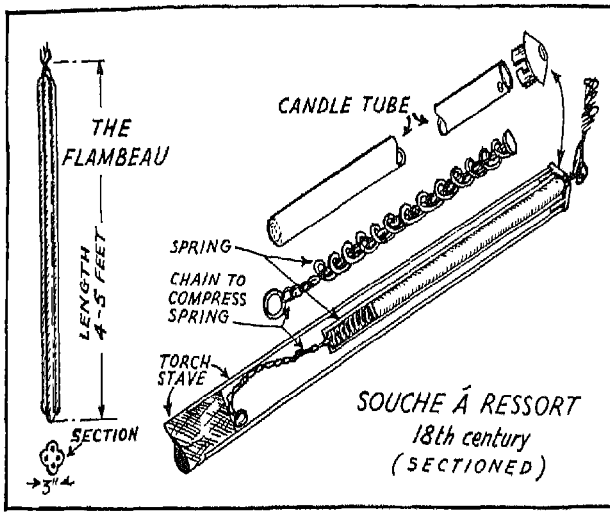


Fig. 23. Flambeau and spring torch.

adequate for the immediate needs of anyone progressing at walking pace. Any light, however feeble, is visible from a long way off; 'orange bright, like golden lamps in a green night' as Andrew Marvell put it in the 17th century.

Carriage lanterns had a more difficult function to perform than hand lamps. To be effective they had to illuminate, for the driver in the driving-seat, the road well ahead of the horses. The ability to pull up before trouble was encountered became progressively less as speed increased. It might be useful to know, from its lights, that there was an oncoming coach in the road, but it would have been more useful still if the road ahead could have been seen. The carters, when they worked by night at all, led their horses and carried horn lanterns, unless, like the present-day bullock-cart driver in India, they were

asleep in the back, but to them a walking speed was fast enough. The coachdriver had to make a fair pace and the lights he had to do it by were very poor prior to the introduction of the Argand burner at the end of the 18th century. Even then the flame at the lens focus, if such a refinement were employed, was only a few times brighter than the inadequate light source available before. It was not sufficiently impressive to prevent the very extensive use of candles right up to the later years of the 19th century in lanterns of such a design that a spring kept the candle-top pressed up against a rim as it burned away, thus keeping the flame at a constant level. Silvered reflectors directed the beam forwards and also outwards through side windows. The lamps were usually mounted at each side below and a little behind the driver so that the sensitiveness of his eye might not be reduced by seeing the rays directly. These lamps were not only used in cities where there might be additional street lighting of a kind, but in the open country as well. The spring-loaded candle holder was used in France at the top of torch staves at least as early as the middle of the 18th century. It was known as the '*Souche à ressort*', or elastic stem. It was round about 1820 that Palmer's spring carriage lanterns began to sell in considerable numbers in England. The fire-engines racing to a burning building in London preferred to rely on links held in the hands of firemen riding on the vehicles (Plate 11).

Some idea of the disadvantages of coach lamps can be gleaned from a rather optimistic account in the *Dumfries Courier* of 1838 of an improved Argand design:

'A splendid article of the kind for carrying her Majesty's mails. The form is circular, with a rather small reflector behind; a funnel and air holes are attached for draught, which force off the smoke so rapidly, that dimming or dirtying the glass and plates within—the great defect of old lamps—are very little, if at all known. In travelling from Edinburgh the road is illuminated from side to side, 100 yards in front, and of the Edinburgh mail thus furnished it may be said, without a figure of speech, that she carries two harvest moons along with her.'

There are many middle-aged and elderly people who will remember when the paraffin lamp, which came in during the 1860s and '70s, was still the commonest carriage lantern. They will remember straining eyes into the darkness of the night beyond the very modest yellow glow that was yet no worse than anything the Edinburgh mail can

have carried. They will also remember how acetylene, so bright and yet now so little seen, was welcomed, about the beginning of the present century; and will remember how even the brightest acetylene lamp hardly showed the road fifty, let alone a hundred, yards ahead. The Bleriot lamp, which was one of the first, was patented in 1900 after four years' development work. In 1905–6 the problem of glare from acetylene lamps was tackled either by fitting the front of the lamp with louvres, or in the design of Messrs. Besnard, to cut off the action of the reflector when required.

Electric lighting for motor-cars came in quite early in the century, the problem of providing constant voltage at all car speeds having been solved by various inventors among whom Vandervell and Proctor, in 1904, may be mentioned. It was in the early 1920's, however, that electric lighting began to forge ahead so quickly that other types rapidly became obsolete. Improvements in lamp bulbs and in anti-dazzle fittings provide a long story of achievement which cannot be dealt with in this publication. It must suffice to say that there still remains a considerable gap between what has been done and the ideal of glareless illumination.

TRAFFIC SIGNALS

Traffic light signals shared in the surge of popularity enjoyed by the electric car lights of the early 1920s. It must be remembered that in earlier days motor-cars, while increasing in importance, were outnumbered on the roads by a great volume of traffic drawn by horses; and neither in power of acceleration nor in speed could the car or goods vehicle of those days outclass the horse so uncompromisingly as the modern machine. The horse, a sentient and intelligent animal that was also under a measure of control by the reins, could negotiate the average crossing safely at the speeds at its command. There were difficulties at major crossings such as that near the Bank of England in London, where many busy roads all led to common intersection. Policemen on point duty were essential at such positions; but at the average crossing there was little to fear. Then, in the 1920s came a great increase of numbers of the popular car; and with it higher speeds, higher accelerations, brakes that could be barely adequate and numbers of drivers unable or unwilling to drive within the mechanical limitations of their vehicles. The higher speeds obtainable, and the ease of generating electricity from a machine driven by the car engine led to a great demand for powerful electric headlights

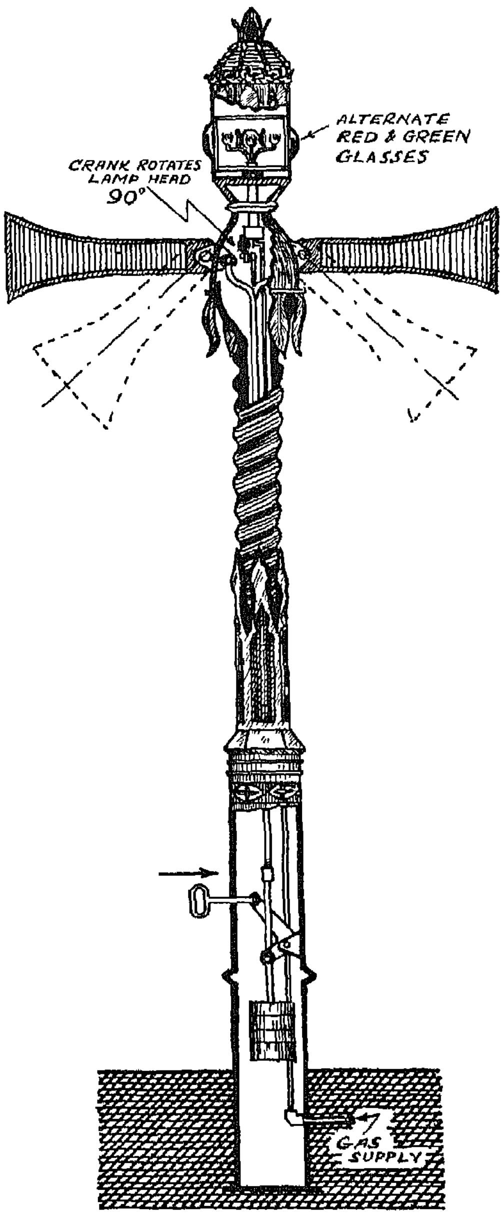


Fig. 24. Gas-lit traffic signal, London 1868.

(from which, in turn, electric lighting of rear, side and internal lamps followed axiomatically). The rise in the volume of motor traffic, quite apart from other factors, made traffic lights imperative in many locations.

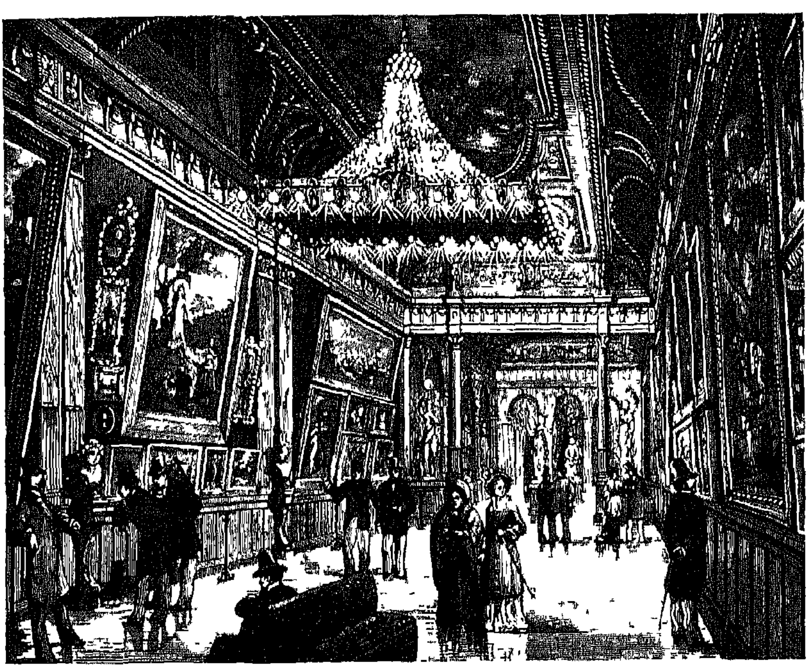
The first installation of the three-colour red, amber and green light signals was at a manually operated set of five control towers erected at a busy crossing in New York City in 1918. The French had a system involving warning bells and one red light only, in 1922. Developments in U.S.A. were rapid, but in Germany there was little to report until 1926; in Britain, 1927; and in Italy, 1931[1]

The earlier automatic traffic lights were time-controlled. That is, a time switch allowed so much time to each direction assessed on the basis of the average traffic each way. This made no allowance for the great variability of traffic density which may arise from a great variety of reasons, among which an outstanding event or sporting fixture is the most obvious. About 1932 the Automatic Electric Co. of Liverpool devised their 'Electromatic' system which found rapid favour. It required, sunk into the road surfaces, vehicle-operated switches which, through ingenious control circuits allowed the time the lights gave for traffic in any one direction, to be related to the traffic density on the road in each direction. This was done by suppressing unwanted 'Go' periods if a vehicle came along on the section of road marked 'Stop'. On simple crossings this is a relatively easy matter, but on multiple crossings becomes very complex.

It will be obvious that the expense of installing automatic traffic lights becomes hard to justify if it is necessary at the same time to retain point-duty policemen; but if the lights save the time and wages of even one such man and do not require too much maintenance, a considerable capital sum may be expended upon them at an eventual saving in money. These considerations did not apply to what may well have been the first street crossing lights under police control. These were outside the Houses of Parliament at the junction of Great George Street and Bridge Street, Westminster, London, and were described in *The Times* of December 9th, 1868. Three fixed gas lights were set in a lantern that could rotate through 90° on the top of a 20-ft. post. Alternate 6 in.-diameter red or green glasses around the lantern gave 'Stop' or 'Go' signs to traffic in each direction as the mechanism was rotated back and forth by a policeman below. The same mechanism operated 4 ft. semaphore arms which were horizontal for 'Stop' and dropped by about 45° (like railway signals) for 'Go'.

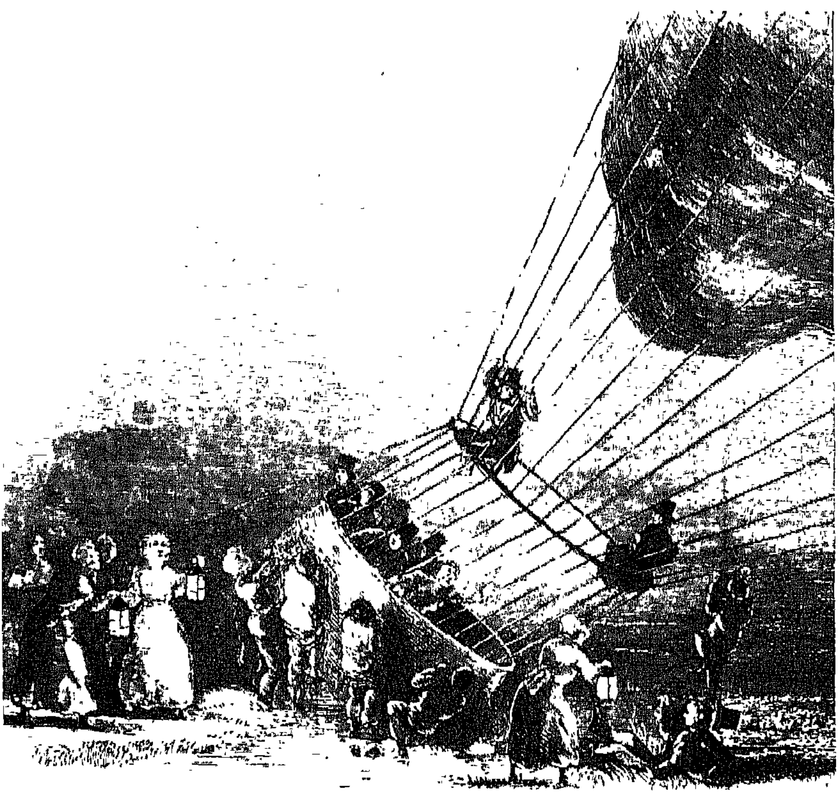
[1] See *Automatic Street Traffic Signalling*, by Harrison and Priest. Pitman, 1934.

New York salon lit by Edison lamps, 1881



Picture gallery, New York City, lit by Edison lamps, 1881

After the Opera, London, 1821 by I. R. and G. Cruikshank



Descent of Mr. Green's balloon at Pirbright, 1852
Illustrated London News

The declared object of this device was to safeguard Members of Parliament when they crossed on foot across a busy traffic stream, but the inventors (Messrs. Saxby, of railway signal fame) hoped in the interests of the public in general and their company in particular that the device would soon be installed all over London. An unfortunate gas explosion injured the policeman and shattered the lantern. As a result the project, although favourably received by the public, was abandoned.

The railway signal lamp was originally a simple oil lamp burning an oil in which seal oil predominated. Later, in the 1860s and 1870s paraffin became more common. Gas was inappropriate for such uses on account of the great expense of piping it and the possibility of failure by leakage. Electricity was similarly in little favour in the earlier years from 1880 to 1920; partly because of expense and partly because of the unreliability of the lamps available. Electric lamps are now made to such exacting standards by the more reputable manufacturers that the risk of failure in the first 75–80 per cent of their rated life is extremely slight. If they are changed, not when they burn out, but after this period of working, they are both economically and operationally acceptable. In both traffic lights and railway signals the use of moulded glass directional lenses is usual. These, with reflectors, give a very powerful beam.

SHIP'S LIGHTS

There is what appears to be a large lantern suspended at the stern of one of the vessels depicted on Trajan's column. Up to a few centuries ago there was so little night sailing that lights were hardly necessary, but Caesar's galleys, for instance, took seven days to cross the Mediterranean to Alexandria and required some visible indications of position so that they should not drift apart during the night hours when it was customary to heave to under the lee of some friendly shore if possible. It must be remembered that right up to the early years of the present century, when radio signalling between ships and between ships and shore became commonplace (after a pioneer effort by Captain Jackson of the British Navy in 1897) a ship below the horizon was completely out of touch. Navigation towards a known rendezvous might result in meeting again later, but naval vessels were safer hunting in packs. In the French Navy in 1543 the admiral's ship carried a flaming cresset[1] astern (unless there were a strong following wind, in which

[1] The actual word used was 'fallot' which is defined in Cotgrave's dictionary of 1611 as 'A cresset light made of ropes wreathed, pitched and put in small cages of iron'.

case it was replaced by a lantern). In Britain a century later lanterns were carried at the poop, and in the rigging of the ship carrying the admiral who expected his flock to be with him still when dawn made it possible to check effectively. Ships' lanterns were very little different from ordinary lanterns except that they had to be larger and more

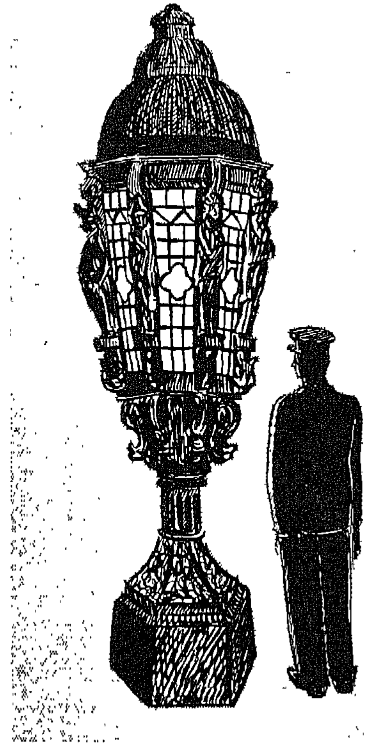


Fig. 25. Stern lantern from flagship of Admiral de Ruyter, 1665.
In the Rijksmuseum, Amsterdam.

robust. Rabelais relates how a ship's lantern was put out by a wave during a storm (*Pantagruel* Bk. IV, Ch. 19).

They were sometimes of amazing proportions. Pepys, when twenty-seven years old, recorded in characteristic vein a visit to the mammoth *Sovereign of the Seas* in 1660. This vessel was built in 1637 and had just been rebuilt when 'the ladies and I, and Captain Pitt and Mr. Castle took barge, and down we went to see the Sovereigne which we did, taking great pleasure therein, singing all the way. And among

other pleasures I put my lady, Mrs. Turner, Mrs. Hempson and the two Mrs. Allens into the Lanthorn, and I went in and kissed them, demanding it as a fee due to a principall officer, with all which we were exceeding merry. . . .' Another record, by Heywood, stated that the ship had five lanthorns deemed capable 'of holding ten persons to stand upright and without shouldering or pressing one the other'.

William Sutherland, in *Britain's Glory, or Shipbuilding Unveil'd*, published in London in 1717, described both upright and raked lanterns for ships. The raked lantern cost 7: 5 in proportion to the cheaper upright. For the largest ships a lantern 4 ft. 2 in. diameter by 8 ft. 2 in. high, cost £23 if raked and might contain two hundredweights of tinplate. The smaller lanterns on each side of the poop were only ⅝ of these dimensions, costing £10 each; while for a small ship only one lantern 2 ft. 6 in. diameter might be carried, and that would cost £7.

The glass used in these lanterns was sometimes 'muscovy glass' (mica) at 5*s.* 6½*d.* to 3*s.* 2*d.* per square foot according to size; or stone ground glass at about 3*s.*; or green glass at 6*d.* to 9*d.* The green glass was similar to that used in many house windows, but was not so well favoured as the dearer varieties. Stone ground glass established itself as the most suitable material of all. A Public Record Office document of 1696 refers to a lantern with stone ground glass according to 'ye new fashion'. It is not fully clear that the glass was new—it may have been the design of lantern.

Despite lengthy searches in the Public Record Office and elsewhere there is still some doubt about the sort of lights these lanthorns carried. It is obvious that a very large lantern would not have been provided for a very small candle and the difficulty of tending a tallow candle during a rough night at sea would alone make wax seem the only possibility. Unfortunately the Admiralty records never refer to wax although there are many references to tallow. These tallow candles were used in the Navy offices and even in the Navy Yards for shipbuilding at night on occasion, varying from eight to the lb. to about a ½lb. each. There are frequent references to lantern repairs, both of glasses and the tin tops and bases. A seriously damaged lantern would be very draughty, which might be good reason to burn torches of the flambeau type. Such a robust flame would need a large container. If heavy tow wicks were dipped in pitch and coated with wax they would burn very merrily, and all the ingredients for manufacture on shipboard would be readily to hand and purchases for the relatively undemanding lantern use would go unrecognized. Perhaps this is the explanation but it is admittedly too conjectural for confident acceptance,

although one large lantern preserved in Denmark contained three very large sockets for candles or torches of some kind. A huge 16th-century hexagonal bronze lantern from the Albrizzi collection in Venice is thought to be from a Provveditore's galley or galleasse. It has a large iron socket of clover leaf section that would be just right for a flambeau (p. 76).

Two contemporary references come from the period when the size of poop lanterns was no longer at its zenith. In 1785 *l'Encyclopedie Methodique* defined, under '*Fanal—Le Fanal de poupe est très grand—on se sert de grosses bougies jaunes lorsqu'on veut mettre de la lumière dans ce fanal*',[1] and in 1820 Vice-Admiral Williaumez in his *Dictionnaire de Marine* says '*Fanal, grande lanterne, aujourdlhui vitrée, on garnit un fanal de grosses bougies en cire jaune, et ils servant deans les escadres a faire des signals de nuit. Il y avait autrefois des fanaux de poupe*'.[2] Yellow wax was cheaper than white wax. There may well have been very stout wicks in these stout candles, so that they would burn with a flambeau-like resistance to draughts.

One record of the late 16th century, when Elizabeth's ships were moored athwart stream in the Medway River, is of 'candles spente in nightlie watches of four ships lying at Chatham for the better suertie and preservacion of the flete there at XIIIs IIIId every shippe for the quarter'.[3] At a cost of fourpence a night, if used on dark nights only, there could not have been any great extravagance about these illuminations. The reference may be simply to the watchmen's lanterns.

The various kinds of lantern used aboard ship were defined and illustrated in the *Naval Expositor* by T. R. Blanckley, which was published in London in 1750. Other details have been found in Public Record Office documents for 1724. Apart from poop and top lanterns the powder-room had a special six-sided type with three sides blank, set at the bulkhead of the magazine and standing, for safety, over a cistern full of water. Presumably access was from the safe side of the bulkhead. The boatswain and carpenter shared a triangular lamp with two quartered glass faces 1 ft. 9 in. high and 11 in. wide on the bulkhead between their respective store-rooms and these two were also allowed

[1] The poop lantern is very large—large yellow candles are used when the lanterns are to be lit.

[2] *Fanal*—a great lantern, nowadays glazed. They are supplied with large candles of yellow wax and are used to make light signals in the squadrons. There are also poop lanterns.

[3] *Administration of the Royal Navy* 1509–1660, by M. Oppenheimer. John Lane, London, 1896.

hand lanterns. The stone ground glass in fixed lanthorns was $\frac{1}{8}$in. thick. Lights below decks were not looked upon with favour for the risk of fire, particularly in heavy seas, was too great. *The Book of War*, by Jehan Bytharne, written in France in 1542, describes how, after the evening hymn to Our Lady the captain must 'put out all the lights in your ship, except those in the cabins of the gentlemen who may have lamps trimmed with water covered with oil, but neither candles nor any other kind of light, by reason of the danger that may arise from them'.

The strict prohibition of a naked flame below decks in the emigrant ships that transported tens of thousands to America and Australia under conditions of the utmost squalor may have seemed harsh, but it was nevertheless wise. A fire at sea, unless there were luck of a most unusual nature, might easily mean the loss of every life on board. There was neither radio nor any other means of summoning help, other than the chance that the fire itself might be seen. Price's, the candle-makers, sold an 'emigrant's safety lantern' for some years before and after the Crimean War (to which they contributed as a gift one thousand pounds' worth ($5,000) to bring comfort to the troops on their journeys by sea). This lantern was a spring candle of robust design in which the door was securely padlocked. Most emigrants, the prisoners for transportation, and all the unfortunate slaves from Africa, made their journeys in unrelieved darkness. We are more ready now to describe such conditions as inhumane than people were at the time. The greatest fear was not so much the lamp itself as that some irresponsible person should carry a naked flame away from it.

In the officers' quarters and the saloons, where the occupants were either more responsible or had paid passage money enough to cover the cost of reliable servants to watch them, lamps were more readily permitted. A lamp suspended from a single point is more or less independent of the swaying of a ship and needs only a stout wire frame to give it added protection. In the 18th century, particularly in the Netherlands, oil lamps set in gimbals were made for ships' use.

For side and masthead lighting lamps were developed that were very strong, with thick glass optically-moulded surrounds for the flame, and were also practically proof against any weather conditions. Inter-linked annular channels were provided for the entry of air and the exit of smoke so that sea-water could not penetrate to the actual combustion area and the draught was practically independent of

wind force. The wicks, of tubular Argand form, required adjustment only once every six hours by means of a milled head situated outside the lantern, but even in the late 1880s such lamps still burned Colza in preference to paraffin. Curiously enough the use of colours—red for port and green for starboard—was introduced only in 1847 despite the hazard that accompanied the use of lamps so identical that the direction of the ship's travel could not be determined thereby. Before steamships came in the rules of precedence for port and starboard tacks were sufficient to avoid collisions between ships using the same wind.

One of the necessities, if not the most important requirement of cross-sea travel, was the ability to read the compass by night. The compass had to be housed away from any extraneous magnetic effects so that all lamp housings had to be of brass or wood. The housing for the compass itself was known as a 'Bittakle' at the time of the naval inventories of Henry VII in 1485. This term has now been corrupted to 'binnacle'. There is no record of the lighting of the 15th-century compass but in Sir Henry Mainwairing's *Seamens Dictionary* of about 1620 there is a clear description:

> 'A bittakle is a close cupboard placed in the steerage before the whip or tiller, wherein the compass doth stand, which is not fastened together with iron nails, but with wooden pins, because that iron would draw the compass so that it would never stand true. These are to be so contrived that they may carry a candle or lamp in them to give light to the compass, so as they disperse no light (further), nor yet let any be seen about the ship.'

Captain John Smith, in his *Sea Grammar* of 1627 gives a similar description while Blanckley's *Naval Expositor* of 1750 refers to 'a sort of locker, framed with deal, to hold the compass, a glass and a candle'. In 1776 William Falconer explained in his *Universal Dictionary of the Marine* that the locker had three compartments with sliding shutters; the two side ones contained compasses and the middle division 'has a lamp or candle with a pane of glass on either side to throw a light upon the compass in the night'.

Early in the 19th century the British Navy used an arrangement devised by one of its senior officers, Sir Home Popham, which was simply a central wick-tube oil lamp shining through an aperture on to the compass card. Similar oil lamps, which had the virtue of being practically unspillable, formed the basis of Preston's binnacle and W. & T. Gilbert's double binnacle in both of which condenser lenses

were used to improve the illumination of the card. On a stormy night at sea the trimming of the wicks of these oil lamps must have been a tricky business and the chance of their being blown out during the process far from inconsiderable. The difficulty of re-lighting them in such circumstances can be imagined. It was claimed, however, that when the best sperm oil was used a wick should last 12–15 hours without trimming. In 1881 electric filament lamps were being installed

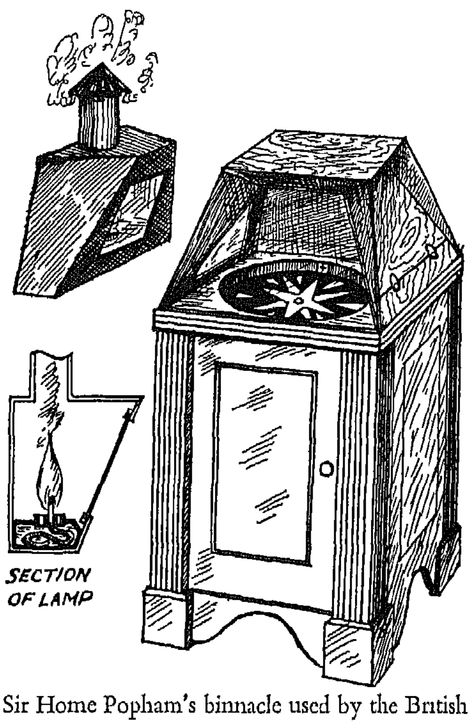


Fig. 26. Sir Home Popham's binnacle used by the British Navy

aboard ship and their application to the lighting of the binnacle must have been hailed with relief at the introduction of a lamp completely independent of the weather that gave an adequate, steady light without coaxing, trimming or attention of any kind.

The first electric installation seems to have been that of Edison lamps in the S.S. *Columbia*, which set off on a voyage round Cape Horn to San Francisco in May 1880. Sixty Swan lamps were installed for the general lighting of the Inman Company's *City of Richmond* over a year later in June 1881. It was easy to generate electricity aboard ship for the steam plant was already there. The lamps

themselves were free from nearly all the disadvantages of their predecessors and their peculiar virtue lay in the absence of a naked flame. Electric lighting was therefore adopted with great rapidity, particularly in passenger liners. Danger of fire from electrical short-circuits still remained and a number of lamentable incidents were experienced before stringent safety precautions became obligatory in the electrical wiring of ships.

MISCELLANEOUS LAMPS

Many ingenious designs have been made to reduce the burden of carrying lamps that would be required only at the journey's end. In

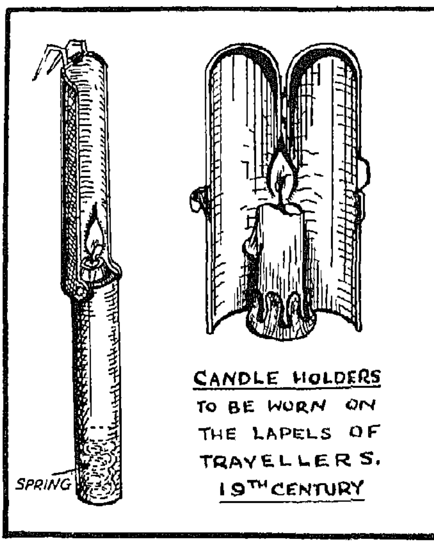


Fig. 27. Candle Holders.

the 13th century candlesticks were made with tripod legs that could be folded up and others were in the form of hollow spikes with pyramidal bases so devised that as many as six would nest together in a space little larger than that required for one. This was a great advantage in those days when luggage had to be carried by a train of pack animals.

In 14th-century Spain candle lanterns were made with hinged faces so that they could be folded almost flat when not in use. Variations on this design have been made in many countries in the centuries

since. One interesting example was designed for the use of railway travellers before the middle of the 19th century. A short candle in a spring holder was concealed by a half-tube which opened vertically when required for use. The half-tube acted then as a reflector for the candle flame. It had a folding pin at the top which could be opened out to attach the whole device to the coat lapel or to the back of the cushioned railway seat. There is no record of frequent disaster from the use of these contrivances, so presumably the railway traveller of those days was less likely to drop off to sleep over his book or newspaper.

Other lanterns were required for use, like the horn lantern, when the holder was actually mobile. In the 16th century, acording to Hartmanus Shopperus (1568), an acolyte would bear a horn lantern slung from a pole when the priest bore the sacrament through the

Fig. 28. Lantern and lantern maker, *from Hartmanus Shopperus,* 1568.

streets to a sick communicant. In the same century, for the use of the priest, a design of oil lamps was produced which persisted for centuries, as ordinary travellers soon began to appreciate its convenience and utility. The oil was in a flat, elongated brass reservoir of rectangular section closed by a screw cap. Around this reservoir fitted a detachable chimney with a bull's-eye on one face. The chimney fitted round the wick tube when required for use and the wick tube itself could be closed by a screw cap when not in use. A cavity consisting of a blind tube concealed within the oil reservoir held wick forceps. The

whole folded up into a convenient box shape and was then leak-proof.

Priests and shepherds were among the relatively few people whose professions made it not uncommon for them to be abroad at night. The shepherd required a stout lamp that would resist ill-treatment and make the risk of starting a fire remote. Such a lamp was described by Henry Stephens in his *Book of the Farm* of 1852. It was 'a stout glass globe that may be knocked against a piece of timber' into which, from below, screwed an oil lamp. A lamp of tin

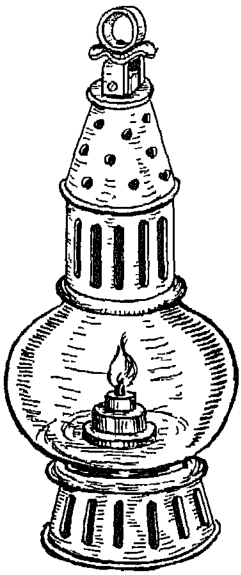
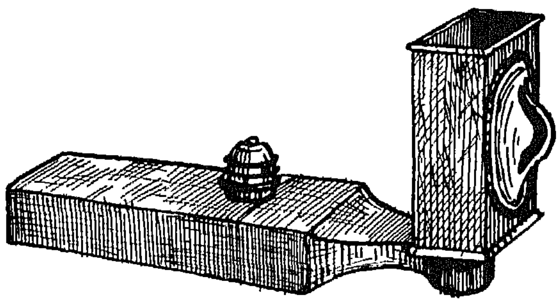


Fig. 29. Shepherds' lamp, 1852.



Brass travellers' lamp.

with a globe 9 in. diameter cost, at *6s. 6d.*, more than half a week's wages of the shepherd, but it would frighten away foxes and be 'a great assistant at night'. A similar type of lamp is shown in a picture of a night flight by the balloonist Charles Green in 1836.

The 'hurricane lamps' of the 1870s burned paraffin and although they were much brighter and quite robust they were probably less safe than the lamps just described. Nevertheless they soon swept the market and disposed of nearly all competition until the squirted tungsten filament of 1907, so troublesome for mains operated electric lamps, proved admirable for the very short filament to work at $2\frac{1}{2}$–$6\frac{1}{2}$ volts. From that time the electric battery torch has increasingly replaced the more cumbersome and less directional hurricane lamp

or the bull's-eye paraffin lamp formerly used by policemen. Bulb life became longer with drawn tungsten (1909) and batteries have improved, but as a warning light the paraffin-burning hurricane lamp still holds pride of place.

PROJECTOR LAMPS

Both ships and railway engines were quite early in the history of electric lighting equipped with projector lamps by which the captain or driver might see the way ahead. In both cases the problem was simplified by the ready availability of steam to drive an engine and dynamo, but the earliest applications were before machinery to provide an electric supply had been invented. In the Mississippi steamboats, early in the 19th century, an iron basket filled with pine knots was swung out on a boom ten or fifteen feet ahead of the bow. Watchmen with buckets of water were always around in case of fire. Electricity soon made such crudities obsolescent. At the siege of Kinburn in the Baltic the French Navy used a battery-fed arc lamp to illuminate the besieged coastline in 1855. Crude permanent magnet generating machines had been devised before the first application of the arc lamp projector to peaceful uses at sea (other than for lighthouse illumination, the origin of which goes back to 1858). The earliest installation was probably that made in 1867 by M. Dubuisson aboard Prince Napoleon's yacht *La Reine Hortense*. An arc lamp mounted in the bows enabled him to negotiate many harbours in the Mediterranean after dark that were normally regarded as suitable only for daylight navigation. Soon afterwards apparatus of a similar kind was installed in six ships of the Compagnie Transatlantique. The sources of power were magneto-electric machines made by the Alliance Company. In 1870, however, the Emperor's new yacht *l'Hirondelle*, managed to damage its stern and part of the customs quay at Cherbourg when making a night entry. Nevertheless this accident did not deter others. M. Menier, the chocolate manufacturer, who in 1875 lit all his factories by electric arc lamps, began by mounting a Brotherhood engine and a Gramme machine in his yacht to supply power to an arc light that enabled him to travel along the tortuous channels of the Seine and the Marne between Paris and his works at Noisiel. The French warship *La Surveillante* used a similar device to light the coast of the island of Tabarka in Tunis to facilitate the landing of French troops in 1880. It was not improbable that the surprise factor in this novelty of warfare contributed as much as anything

to the ease with which an objective that had been expected to be hotly contested was gained. The British Navy used the same technique during the war with Egypt.

In the early 1880s a small high-speed steam launch was used to approach an ironclad and place a torpedo under it. The idea was that the launch could approach and get away without being seen and, when far enough off, could explode the torpedo by electricity. The self-propelled torpedo was a horror of the future, but even the threat of this clumsy method of assault was sufficient to make it imperative that every ironclad should carry at least one searchlight.

The first electric locomotive headlight was probably that made by Sedlaczek & Wikullil in 1881 and shown at the Paris Exhibition. To damp out vibration the carbons were mounted on pistons within tubes of glycerine. It was claimed that tests in Austria and France had shown that at night, or in dark tunnels the way ahead could be seen for a third of a mile. Acetylene, which was later used to some extent, was dependent upon supplies of calcium carbide which could only be provided after the success of the electric furnace experiments of Moissan & Willson in 1892.

The lighting of railway carriages electrically was another case in which effects of vibration were far from negligible. The early spring lamp holders of Swan proved admirable in this respect, but when filaments became more robust they were able to withstand vibration without special precautions. The Pullman Car Company used Edison lamps in its carriages as early as 1881. They were fixed in the old oil lamp supports and even used the same shades and were powered by great batteries of fauré cells slung underneath the coach. On the London–Brighton run in England a decade or so later a Siemens dynamo in the luggage van was coupled to the wheels of the train and charged a secondary battery during the journey; by 1901, throughout the world, there were 12,000 railway carriages lighted electrically of which half were from dynamos and batteries and the other half from batteries alone. There was originally no light at all in German trains, but in 1844, the King of Prussia ordered it 'for the sake of safety and decency'.

For some years before that, in British railways, there had been some trains lit by pot lamps, burning vegetable oils, dropped through a hole in the roof. A first class compartment had one to itself; two second class compartments shared one at the partition; and for the whole third class carriage there was but a single lamp. In 1863 coal gas, contained in collapsible rubber bags in flat oblong boxes on the

roof, was used to light the carriages of the Metropolitan Railway in London. The American Pullman cars (imported into Britain in 1874) used kerosene lamps.

STREET LIGHTING

The lighted street is an obvious and necessary adjunct to travelling about, but fixed lighting in the streets has for thousands of years proved to be beyond the technical and economic competence of man apart from a number of attempts of varying degrees of dullness. Crowds at festival times may have justified the thick tow wicks burning in bowls containing a hundredweight of fat in each at ancient Babylon, but at ordinary times such expenditure would have been regarded as prodigal. There was, for instance, no street lighting in Imperial Rome and according to Juvenal to go out to supper without having made your will was to expose yourself to the reproach of carelessness.[1] Travelling at night was not usual among ordinary folk and if they did intend to make a journey there was not such time-compulsion as there is today. A visit could be planned for the time of the full moon More important folk might have attendants with torches and even the humblest night, in emergency, provide himself with a torch of resinous pine or other inexpensive material to light him on his way.

St. Jerome, in the 4th century, said that in his time Jerusalem was lit by wood fires at the cross-roads, but it is uncertain whether he referred to festival times or to ordinary occasions. In the same century, according to Libanius 'to a bath not far off they cut with their swords the ropes from which were suspended the lamps that offered light in the night time' in Antioch.[2] The Justinian Code recognized street lighting as a tax item, but again it may have been festival times only that were involved. It is said that the Arabs paved and lighted miles of streets in Cordova in the 10th century.[3] There were lamps at cross-roads in the streets of Paris in the 13th and 14th centuries, but these were to light 'Madonnas' set up by the faithful. Maintenance of these lights was often imposed as a penance by the father confessors. The custom of setting up such emblems was revived in the 16th century by Louise de Lorraine, the wife of Henry III of France.

[1] *Daily Life in Ancient Rome,* Jérôme Carcopino. Pelican Books, London, 1955.

[2] *Libanii Opera Lutet,* 1627.

[3] *The Arabs,* Edward Atiyah. Pelican Books, London, 1956.

In London the populace was not encouraged to wander about at night. A statute of Edward I (1272–1307) ordered that 'none be so hardy as to be found going or wandering about the streets of the City after curfew tolled at St. Martins-le-Grand, with sword or buckler, or other arms for doing mischief, or whereof evil suspicion might arrive, nor in any other manner, unless he be a great man, or other lawful person of good repute, or their certain passengers having their warrants to go from one to another, with lanthorn in hand'.

In the year 1405 the Court of Common Council decreed that a lighted lanthorn should be set outside every house for the Christmas Watch. Later the same order was given for Saints' Days and by 1415 all householders rated at £10 per annum or more were ordered to hang out a lanthorn burning a candle of not less than 10 to the lb. each winter evening between All-Hallows and Candlemas. This order was not as effective as it might have been, for there were few houses rated at £10 or over and it soon fell altogether into desuetude. For three hundred years there were sporadic attempts to enforce it, but always without lasting success.

Paris experienced the same troubles. Louis XI ordered citizens in 1461 to place '*flambeaux ardens et lanternes*' at cross-roads and in the windows of houses. The Watch, in Paris, had patrolled the streets after dusk in winter and after curfew in summer since 1363 bearing flambeaux to light the way and halberds with which to attack the all-too-frequent bandit gangs. A shield of the time bears a hook in the centre from which a lantern might be hung. In some streets, called '*rues de la lanterne*', lanterns were actually hung in the windows of houses, but all these efforts were brought to nothing by the increasing temerity of the bandits. A decree of 1524 ordered lanterns in the windows and buckets of water by the doors as protection from the bands of incendiaries who set fire to houses to pillage them and their fleeing inhabitants. These orders were many times repeated. Conditions in London were little, if any better. As late as 1744 the Lord Mayor and Alderman were complaining 'that divers confederacies of great numbers of evilly disposed persons, armed with bludgeons, pistols, cutlasses and other dangerous weapons, infest not only the private lanes and passages but likewise the public streets and places of public concourse'.

In both London and Paris attempts to make street lighting more effective were made in the 17th century. London, in 1657, laid a charge upon its Aldermen to provide lights at public expense at places where the individual citizens could not be called upon to do so. The

citizens still had responsibilities and a watchman's song of this period ran:

> 'A light here, maids, hang out your lights,
> And see your horns be clear and bright
> That so your candle clear may shine
> Continuing from six to nine
> That honest men may walk along
> And see to pass safe without wrong.'

In Paris the Abbé Laudati got letters patent giving him a monopoly to hire guides with hand lanterns to travellers by night. Between 1662 and 1682 he established watch posts 300 paces apart and charged 5 sols for fifteen minutes to a carriage and 3 sols to a pedestrian. The watchmen were not only prepared to resist attack, but could quickly get help from the nearby watch posts. In addition, from 1667, the lieutenant of police, M. de la Eyrnie, insisted that glass candle lanterns should be suspended at first-floor level in each street, each containing a candle of 3 to the lb. that would last until after midnight. The King, Louis XIV, backed him in this and recouped the £50,000 that it cost over the five winter months each year by means of taxes. The tax was so successful that in 1688 the King obtained £4,000,000 by selling the rights in them to entrepreneurs all over France who were charged, on recoupment, with the duty of lighting each town in the provinces. About this time Paris alone burned 1,625 lb. of candles every night in 6,500 lanterns.

By 1763, according to *The Gentleman's Magazine* (Vol. XXXIII, p. 295), there were still 6,500 lanterns in Paris, but they cost only £13,125 per annum. Lanterns were suspended 15 feet high and 15 yards apart in 'the middle of a cord that reaches across the street, and is fixed to pulleys on each side'. They were lit only on twenty nights a month from September 30th to April 1st. Other nights were deemed sufficiently lit by the moon. Each lantern consumed 50 candles in a season, of 4 to the lb. on moonless nights and 8 to the lb. when the moon was segmental. 'The proper officer sends out a person ringing a hand-bell through all the streets to give notice of lighting them.' Notice was to '*lanterniers*' annually chosen in each quarter and each responsible for 15 lanterns. To these officers candles were issued each Saturday, 'but the light is not comparable to that of the lamps in London' even though the whole city might be lighted 'in the space of a few minutes'. At that time there were 29,000 houses in Paris sheltering 580,000 inhabitants.

London, meanwhile, experienced the Great Fire of 1666, which destroyed so much of the central area that street lighting there would have been superfluous; but by 1694 it was sufficiently restored for a license to be given to one Edward Heming to place lights before every tenth house from 6 p.m. to midnight between Michaelmas and Lady Day, and to charge 6*s.* per annum to each householder. He began, a couple of years earlier, by experiments with oil lamps, but the Tallow Chandlers at once protested to the Lord Mayor, Aldermen and Commons 'That this Company have been incorporated for 230 years and are now become a numerous body, several of whom have been called to and served in the greatest places of trust and honour in this city . . . thought themselves safe from any invasion of their laws, one of which is an Act of Common Council made the 3 of October 1599, whereby every householder from the 1st of October to the 1st of March in every year for ever should cause a substantial lanthorn and a candle of eight in the pound to be hang'd without their doors'.

'That notwithstanding the said Act, still in force, certain unfree men who are not capable of serving any office in any company nor office of trust within this city . . . have set up, and do continue, in the streets of this city and liberties thereof, a great number of convex lamps and other lucidaries.

'That the aforesaid lamps or lucidaries are merely novel, and should they be encouraged they will cause many more such intrudings upon other arts and mysteries.

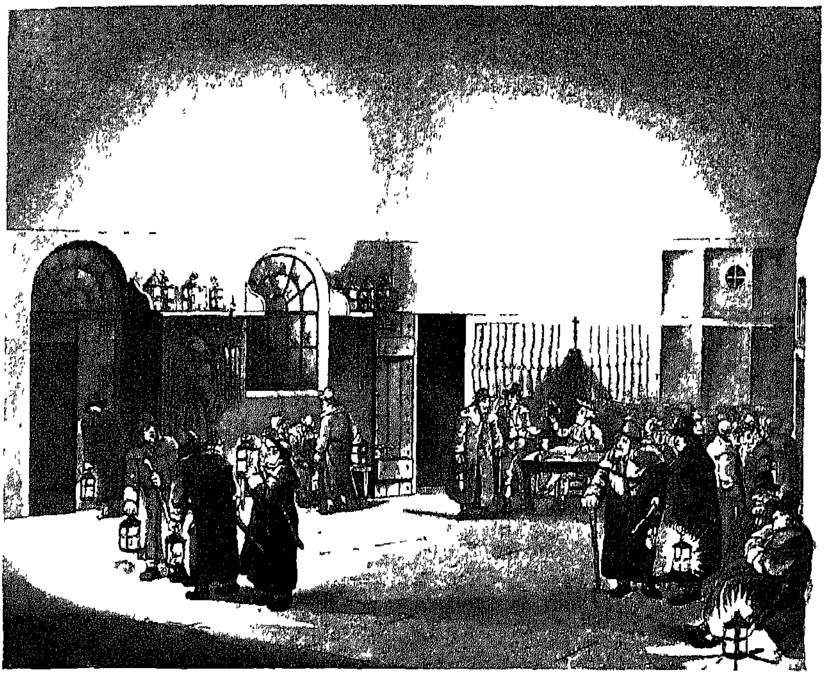
'That the setting up and use of the said lamps within this city and liberties for the time past have been and for the future will be a great prejudice . . . first, to this company—and to other Trades as the Horners in making leaves for lanthorns for burning candles in, tinmen, and spinners of cotton whereof the twentieth part is not, nor cannot be used in lamps as it is in candles.

'That all monopolies in all ages have been extreme destructive, oppresive and against the rights of the subjects, and of Magna Charta.

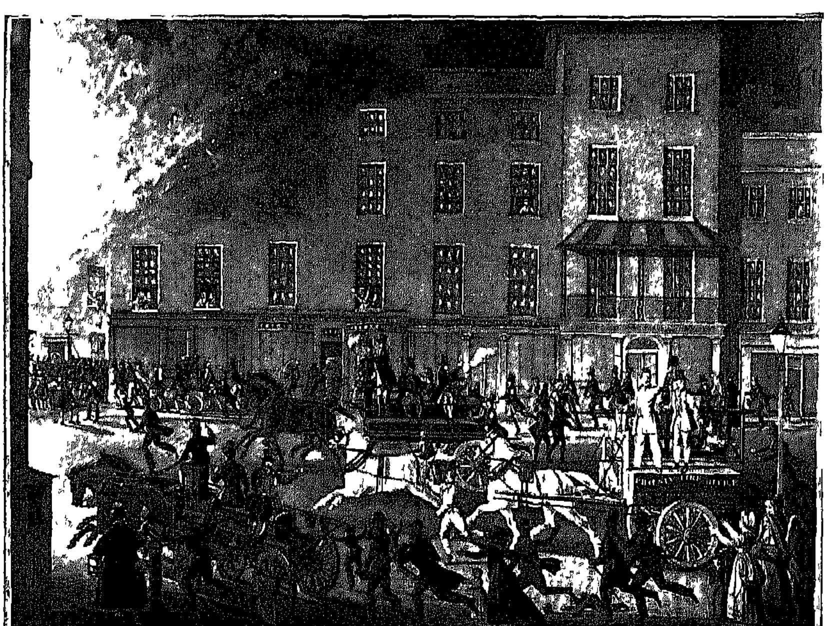
'It is humbly hoped that projects so pernicious to the publick good of the Kingdom . . . will not find or receive any encouragement in this city.

'Tallow candles in lanthorns . . . will be cheaper to the inhabitants than any sort of lamp'.

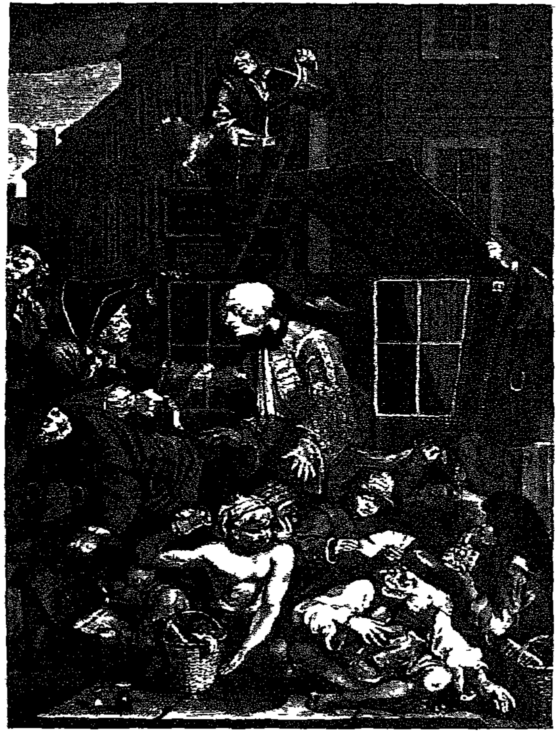
The chandlers, in spite of this moving appeal, failed to prevent the



The Watch House, St. Mary le Bone, 1809 by Pugin and Rowlandson



London Fire Engines



Spilling the Oil. From Hogarth's *Rake's Progress*

The Bull's Eye Lantern, 1872 by Gustav Doré

concurrent development of the oil lamp, such as the one in Hogarth's 'The Arrest', painted in 1735.

The Admiralty for once seem to have lost their conservatism at the advent of Heming's lamps. By 1696 they had placed a single 'convex lamp' above the main gates of Deptford Dockyard near London. In 1707 a correspondent to the Admiralty recorded that there was still only this one lamp (for which ten gallons of rape oil were ordered in 1702) and recommended that two more should be 'set up in convenient places in the yard, kept burning on dark winter nights so the watchman may be better enabled to prevent any ill designs on H.M. ships in the dock and magazine if attempted'.

In 1716 Heming's licence was revoked (probably as the result of unremitting pressure by the candle-makers) and the citizens were again called upon, but again unsuccessfully. Daniel Defoe, in 1729, published a pamphlet decrying the robbery with violence taking place in the poorly-lit streets. Contractors with a right to call upon householders for dues then paid £600 a year for the privilege and did very well out of it, but the lighting was still poor. Finally, in 1736, the city took over the task itself, and installed 5,000 lamps in the streets. This was five times the previous number but in two years even this figure was trebled and in spite of the Tallow Chandlers' protests they again seem to have been oil lamps if Hogarth's paintings of 'The Angry Musician' (Plate 27b) and 'The Arrest' in *Rake's Progress* series can be taken as a guide (Plate 12). Oxford Street alone was reputed to have more lamps at this time than the whole of Paris. Even so there was plenty of demand for the services of link boys. The street lamps gave distant comfort and preserved the traveller from the dire and inevitable consequences of complete surprise, but they did not adequately light the potholes in the road. The flaring links were also a discouragement to the lurking thieves and purse snatchers investing the gloomy corners of a city that had to wait almost another century before it could boast a properly organized and effective force of police. Towards the end of the 18th century the street lighting of London passed to the control of a body responsible for many other communal benefits. The title 'Commissioners of Sewers' may seem uneuphonic, but the activities of these gentlemen were greatly to the public good.

Experiences similar to those in London and Paris can be quoted from other towns. A contrary argument was surprisingly put forward in Cologne as recently as 1816 when it was suggested that the provision of gas street lighting would frighten horses and be an aid to thieves and cut-throats. In the 17th century there was no such illusion. Street

lighting was looked upon as the only answer to disorder and there are records of excellent lighting from oil lamps in Amsterdam in 1669 and in lighting at Hamburg, 1675, Vienna, 1687, and many other towns in Europe about the same time.

A very significant step towards better lighting took place in London in 1805. Winser, as part of his propaganda towards the flotation of the National Light and Heat Company, exhibited a number of gas lights along the wall of his house in Pall Mall on the occasion of the King's birthday. There was an interval of four years before the same street had the honour of being the first in the world to be permanently lit by gas. Developments were fast, and by 1823 there were 39,504 public gas lamps lighting 215 miles of London's streets for which 68,000 cubic feet of gas were generated nightly. Gas lighting spread to the provinces and abroad. Soon there was hardly a town of importance without its gas lamps in the streets. The watchmen in London might still carry horn lanterns and rattles to rotate when they needed assistance, but in many streets the new gas lighting dispelled a gloom that was previously the watchman's enemy.

Two developments about the middle of the century are worthy of mention. Both were the inventions of William Sugg, of London, and of the two the steatite orifice gas burner of 1858 was probably the greatest boon. No longer did the burners corrode into ineffectuality and the steatite, by cooling the flame less, increased the brilliance of the light. The gas governor or regulator, by controlling consumption, added constancy to the light and economy to the process of feeding it.

The next most important stage in gas lighting came at a time when the competition of electricity threatened to drive gas from the streets; the Welsbach mantle (usually called the Auer mantle in many European countries) enabled gas to re-establish itself in the last decade of the 19th century. The greater efficiency of the incandescent mantle enabled a sufficiency of light to be obtained at reasonable cost. This, combined with the fact that gas supplies were already laid to the lighting points, tipped the economic scale to some extent away from electricity. Even today, although new types of electric lamp are exploited in conjunction with admirably convenient and scientific means of controlling the light output into the directions desired, there still remains a considerable field for gas lamps where installations already exist. Not all roads need be nor can be lit to main arterial road standards. The economics of street lighting is a matter of technical calculation, and gas should not be ignored. At one time, about the end of the 19th century, even the

waste heat from street gas lamps in London was considered economically. One optimistic project provided penny-in-the-slot lamps from which a cup of tea could be drawn.

Electric lighting in the streets began with the arc lamp. At first there were no dynamos to give the power required to feed the arcs, and such demonstrations as were given, using batteries of wet cells, were more impressive than effective as an economic proposition. In Paris Messrs. Deleuil & Archereau gave such demonstrations as early as 1841–4 at the Quai Conti and in the Place de la Concorde. The arc was struck in an exhausted glass globe so as to lessen the rate at which the carbons would be consumed. W. E. Staite showed his arc lamp from the north tower of Hungerford Bridge, London, for three hours in each of fourteen consecutive evenings in 1849. In 1852 it was proposed to try such a light, battery fed, at the top of a tower at Liverpool Docks but Staite, who had successfully demonstrated his arc lamp for dock work to the Commissioners of the river Wear in Sunderland in 1848, died before the Liverpool project materialized. The idea was taken up again in 1855 by Messrs. Lacassagne & Thiers of Lyons who lit the Quai des Celestins there. The French press was enthusiastic and in 1856 the Champs-Elysées was lit for four hours from an arc at the top of the Arc de Triomphe. The next year two lamps were installed as permanent illumination in the Rue Imperiale at Lyons. By 1860 the economic disadvantages had killed a proposal doomed from the start by the absence of dynamo electric machinery.

Electric machines of cumbersome weight and low efficiency were available in both France and England at this time, but they were regarded as attractive only where tremendous advantages from the light outweighed the cost of running them. Lighthouses and warships were the first applications. It was the Gramme machine of 1870 that altered the outlook and the Jablochkoff candle of 1876 that transformed it by providing an arc that could be run off alternating currents without complicated regulating gear or any attention other than a periodical renewal of the carbons. In 1878 the Avenue de l'Opéra in Paris was lit by 62 Jablochkoff lamps (Plate 14b) and in 1879 1¼ miles of road in London, from Westminster to Waterloo, was lit in a similar way by 40 lamps.

In the United States, a few months earlier, Wabash, Indiana, set up a municipally owned electric light plant to supply a few 'Brush' (Plate 14a) arc lamps. The Brush Company was outstandingly successful in U.S.A., for 25,000 of their lamps out of a total of about 90,000 were burning every night in 1884. Not all of these were for street

lighting but Mr. (later Sir William) Preece, writing in the *Journal of the Society of Arts,* London, for December 5th, 1884, recorded his impressions of a journey from U.S.A. to Britain the previous October:

'I know of nothing more dismal than to be transplanted from the brilliantly illuminated avenues of New York to the dull and dark streets of London. This happened to me very recently. I drove from the Windsor Hotel, New York, to the Cunard Wharf, a distance of about 4 miles through streets entirely lighted by electricity. I drove

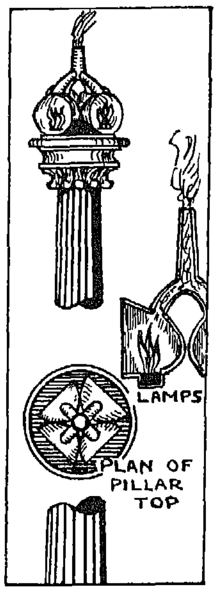


Fig. 30. (*a*) Area lighting by oil lamp, 1763.

from Euston to Waterloo (London) without seeing a single electric light.'

The street lighting in U.S.A. was nevertheless all by arc lamp, with not a single instance of glow lamp lighting. The cost, usually, was 60 to 70 cents a night to municipal authorities maintaining 25 lamps or more, and a dollar a night for a single lamp. Even then the hours of use were limited, with everything shutting down at midnight.

Most of the arc lamps were at the top of tall iron tubular poles, but some attempts at area lighting are well worth recalling. In *The Gentleman'sMagazine* of February, 1763, a proposal was made to light whole city areas by four oil lamps, each at right angles, in parabolic reflectors mounted at the tops of high pillars. In America, using arc lamps, this

scheme actually came to fruition. Masts 250 feet high were built in Cleveland from riveted boiler plate. The top section, 8 inches in diameter, was made first and then lifted by jacks on to the section beneath, and so on. The pavement level section was of 3 feet in diameter. Foundations must have been impressive, even if the whole structure were stabilized by stay wires. The masts cost nearly 4,000 dollars each and on top of them were 8 'Brush' arc lamps. That was in 1884. A little later New York City used the same system, with masts a mere 160 ft. high, for the area between Madison and Union squares. Mr. Preece did not think very highly of the result which he compared with pale moonlight.

The same technique was used in slightly different form in San José,

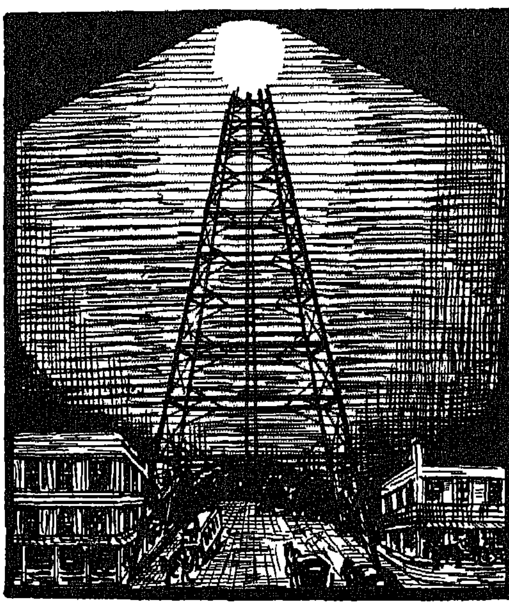


Fig. 30. (*b*) Arc light tower in San José, California, in 1885.

California, in 1885 and in other places later. Here the towers were fabricated so that they straddled the main street and stretched up a couple of hundred feet into the sky with arc lamps at the top. They may have been reasonably consistent in the results obtained, but in localities where mist or fog was more prevalent they were quite useless just when they were most required. The ordinary pole-top mounted light was more practical and of these the Police Chief in New York

City said 'every electric light erected means a policeman removed,' thus confirming what had earlier been said by Emerson about gaslight.

The effect of all these installations in U.S.A. was an overhead wire congestion in the cities that is difficult to imagine. In England overhead wires were banned by law, or at least it was difficult to obtain permission to erect them. In the U.S.A. thirty-two separate companies purported to serve New York City alone and Preece counted six separate lines of posts down Broadway and as many as 144 wires

Fig. 31. Lower Broadway, New York City, about mid-1880s.

on each post. Most, but by no means all of these were for telephones and telegraphs. This chaos was gradually resolved, but even in 1884 there were many references to the elegance of the 82 Weston arc lamps lighting the Brooklyn Suspension Bridge. The number of arc lamps on the Edison system alone never fell below 35,000 in the years 1907–14, after which the filament lamp began to reduce the territory served by arcs. In London by 1913 nearly all the City streets were lit by flame arcs.

Electric filament lamp street lighting probably starts with the

hopelessly uneconomic installation by Lodyguin at the docks of St. Petersburg in 1872. He received a substantial award for his work, but like the arc lighting of Lacassagne and Thiers it could not stand up to the test of continuous running. Much more promising efforts were the use of Swan lamps in Newcastle, in 1881 (Plate 15a) and Edison

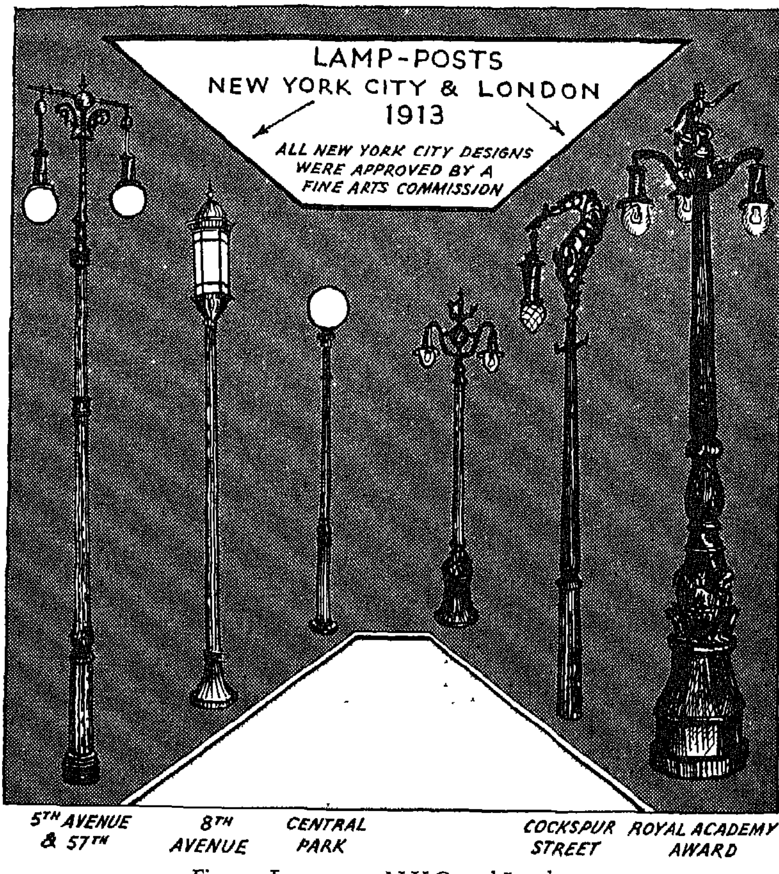


Fig. 32. Lamp-posts N.Y.C. and London 1913.

lamps in Munich in 1883 at the time of an electrical exhibition in that town. There is little to say about the later applications of filament lamps to street lighting. Developments in the lamps themselves, dealt with elsewhere, provided increasingly effective tools which technicians were not slow to adapt to street lighting as well as many other uses. The continual improvements in reflectors devised to throw the light where it is wanted and to reduce maintenance costs is a story too technical to be included in this volume. Nor is it possible to discuss

details of lamp standard designs. These, in New York City, were subject to the approval of an Art Commission as early as 1913[1] and there is little doubt that some control over aesthetic considerations has been fruitful wherever it has been imposed.

It was about 1932 that British laboratories produced high-pressure mercury vapour lamps and sodium lamps that began in a small way to attract notice which resulted, a couple of years later, in their rapid adoption for street lighting. They are both poor for colour rendering (and sodium particularly so) but the efficiency of the driver by night is practically unaffected by colour. Their light is not very pleasing and it is largely for this reason that fluorescent tube lighting of roads was tried out experimentally in Britain about 1947 and has since been adopted in many thoroughfares where colour and comfort are regarded as important. So far it is economically at some disadvantage compared with the plain discharge lamp.

It may help towards a comparison of old and new street lighting to appreciate that, quite apart from present-day scientifically designed lanterns that collect light from the source and distribute it just where it is wanted, the light output from a single 400-watt mercury lamp is equivalent to the light of about 1,500 candles. Even a 150-watt tungsten filament lamp is equivalent to about 170 candles and its old-fashioned carbon filament predecessor of the 1890s would probably outshine a quarter as many.

AERODROME LIGHTING

The first 'aerodrome' lighting may well have been that during the 1870 siege of Paris when many balloons were sent up by the light of lamps at night to carry mail and passengers out of the city. Lighting to aid incoming aeronauts started in Germany in 1909 when letters with prismatic reflectors and filament lamps were lit at night as a guide to airships.

Prior to 1914 there were a few night-flying exhibitions, notably at Hendon, London, in which aeroplanes were outlined by small electric lamps and landed by the light of tow burning in a bucket of paraffin. During the war that followed, lines of flares—paraffin or electric—were laid down to help night-flying pilots to land, and lighthouses directing their light to the sky were laid down across France to guide the pilots home. They also guided the enemy on bombing raids.

[1] *Street Lighting of Greater New York.* C. F. Lacombe, Trans. Am. Ill. Eng. Soc., May, 1913.

Beacons of the searchlight type became common, but the pilot was liable to find himself outside the effective area of the narrow beam. In December, 1919, the Gas Accumulator Company provided a true beacon light at Hounslow aerodrome, near London, and when Croydon replaced Hounslow as the continental traffic centre in 1920 it had similar beacons, obstruction and boundary lights, a landing flood-light and an illuminated wind indicator. Progress after that was slow although the way to international agreement was paved at a conference of the International Illumination Commission in U.S.A. in 1928. Progress in U.S.A. was thereafter more spectacular than elsewhere, and at the Curtiss-Chicago airport opened in October, 1929, the lighting was on a very substantial scale. Thirty-nine 1,000-watt flood-lights illuminated the hangar, upon the roof of which was a 2,000,000 candle-power green-flashing beacon. A white revolving beacon of similar power topped the smoke stack. Thirty-five red lights indicated wind direction and a very powerful arc lamp, for which 3-kilowatt filament flood-lamps could be substituted in the event of failure, flood-lit the whole field.

Flood-lighting of the landing area proved not to be the perfect answer as the pilot had little information as to his distance from or above the touchdown area. The rags or tow burning in a bucket actually gave a more definitive signal and systems were therefore developed in which the aircraft was led up to an outlined runway along a line crossed by other lines of light at right angles; the apparent dimensions of the succeeding lines gave the pilot a very good idea of the correctness of his approach.

Nowadays aerodrome lighting is highly specialized, employing filament lamps and both mercury and sodium discharge lamps. Runway lamps are in special dome-topped fittings over which the aricraft can actually ride without damage to the fitting or itself, or else in fittings so light that an aircraft could demolish them easily. The aircraft carries its own landing lights in addition to those on the ground, while cabin lights, navigation lights and lights for the various instrument panels have all been the subject of successful research.

CHAPTER V

Light for Work

THE smith or armourer, in a crisis, might work at night by the light of the forge and perhaps a candle or two; but in olden days work after dark was a rarity.

But there still remained the inescapable tasks. The shepherd at lambing time and the cowherd at calving time might well be called in the dark hours. A naked flame was to be feared. 'Feare candle, good wife', said Thomas Tusser in 1571, 'feare candle in hay loft, in barn or in shed.' The shepherd therefore preferred a lantern and for country folk as well as townsmen the horn lantern became a very commonplace possession.

The lantern was a working tool. There was not a great deal of light-burning for pleasure among the masses to whom the light of a fire was sufficient for most purposes. The number of literates was small for a long time after the invention of printing from movable types in the 15th century. Although Gutenberg's success may have made books available to many, they were still out of the reach of the majority. In the 18th century John Gay was able to ask:

> 'Whence is thy learning? Hath thy toil
> O'er books consumed the midnight oil?'

It was the exceptional man that studied so; and among manual workers virtually none could read at all. There was not even a great expenditure of light on entertainment among the masses; although aristocratic households may have been prodigal sometimes in that respect. The inns had to entertain travellers and they necessarily kept their public rooms lit up; but other parts of the premises remained in darkness. The scale of lighting in the public rooms was rarely lavish and there was usually but a single candle for the traveller to light himself to bed. By 1821, when George and Robert Cruikshank illustrated Pierce Egan's *Life of London*, the night constable in the watch-house enjoyed

the light from a gas jet in a glass chimney with a vent pipe above to carry off the products of combustion. The same lighting might be found in the gin palace near the Opera and at a disreputable grog shop in the East End. The pothouse in the 'back slums' was shown with

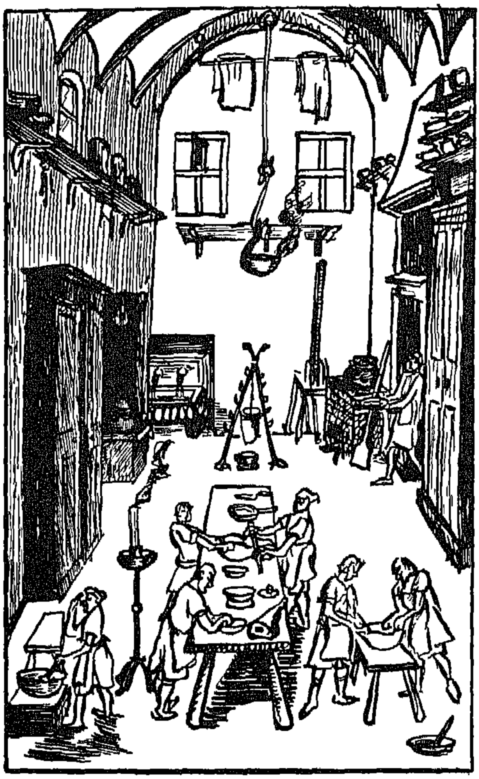


Fig. 33. Kitchen scene, 1570.

the crudest spout-wick oil lamps and the Green Room at Drury Lane Theatre rejoiced in the more aristocratic Argand oil lamps. In all these cases the degree of illumination cannot have been other than very modest (Plates 16 and 17).

The idea of squandering light for entertainment was looked upon with disfavour. There is a deprecatory air about the report of Antony's dalliance with Cleopatra:

> 'He fishes, drinks
> And wastes the lamps of night in revel.'

Where lights were burning it was more commonly to help with domestic tasks. There has already been described the scene in the kitchen of a wealthy yeoman at Parham, in Suffolk, in 1791, with his wife and all the servants sewing by the light of a single candle. Pierre de Ronsard, in the late 16th century, described another domestic scene:

> 'When you are old, and in the candle light
> Sit spinning by the fire at close of day.'

Even as late as 1851 Ludwig Richter drew a peasant scene in Germany with the housewife spinning by the light of the pine splinter that sufficed for the whole room. Laplanders in quite recent times worked by the light of such splinters held in the mouth. The kitchen might also be used at night for the preparation of meals. A drawing by

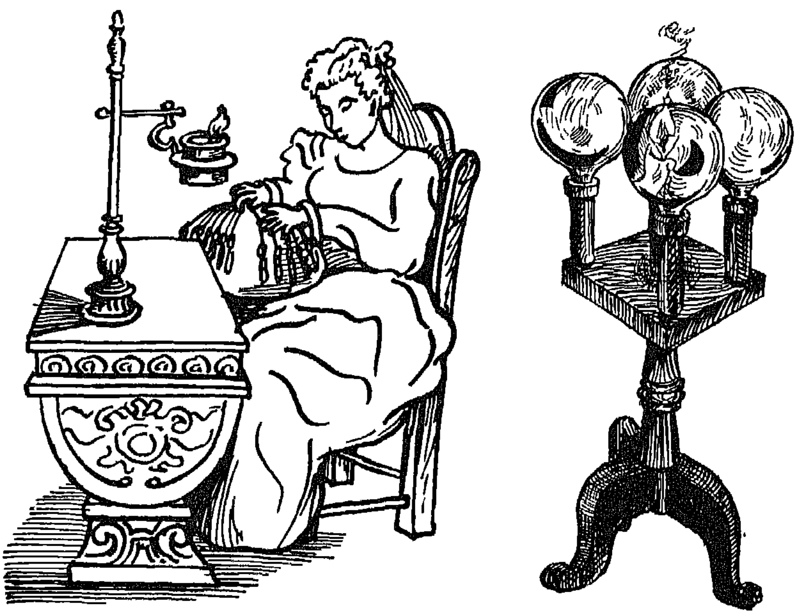


Fig. 34. Lace-making, 16th century. Condenser Stand, 19th century.

Scappi in 1570 shows a large kitchen with seven domestics busily engaged in the preparation of a meal. Apart from the great fireplaces and a separate brick oven beneath which another fire burns, the illumination was from a cresset suspended from the middle of the

high ceiling and a stout candle in a tall stand set where it would best illuminate the kitchen table. (Fig. 33.)

All these uses of light were for work of a sort, but it is a far cry from those to the factory production with which we are today familiar. The dividing line between domestic and factory applications is anything but clear cut. An example may be drawn from the extensive cottage industry of lace-making. Fine lace means very fine work, for which good light is essential. The best light available in the 16th century was a pan lamp with a robust wick. Presumably the skilled hands of the lace-maker could be relied upon to function automatically with light required only occasionally for adjustments and re-threading. With children in the lace schools such facility could not be expected and the light from a candle was concentrated on their work by means of a condenser lens formed by filling a spherical flask with water (Plate 3*a*).

The origin of the 'lace-makers' condenser' seems to have been early in the 17th century when it was applied to quite different arts. The reference in the *Treatise of Metallica* published by John Rovenson in London in 1613 reads:

'For such of the workes as require light to worke by in the night, being distant from the places where the furnaces are, there is a new-devised luminary of glasse, or glasses filled with water & a candle placed to give light through it, which giveth a very great light a distance off, with small charge; and may be converted to excellent use, being placed in high places at cross-wayes, and streets of citties and townes, to the saving of lanthorne and candle-light and the avoiding of inconveniences happening by darkness.'

Such a condenser was shown in a still life painted by Jacques de Claew in Amsterdam in 1650. It was part of the fitments of a Dutch lamp mounted with the usual other accessories on a stand. A full and entertaining description was given by John White of London in *A Rich Cabinet with Variety of Inventions* published in 1651. Under the heading 'How to make a glorious light with a candle like sunshine' he says:

'This is a rare conceit, and fit for those artists or others that perform curious and fine works by candle light, as Jewellers, Ingravers, or the like, or those which are weak sighted to reade by, never dazeling the eye.

'Go to the Glass-house, or Glass Shope and let them blow you a

thin round Globe glass, bigger than a penny loaf (the bigger the better, with a short neck like a bottle, they know how to make them).

'When you have this Glass, with Glew or Wax, bind a piece of tape or pack thread about the neck or top, making a little loop there-with to hang by; then fill your Glass with the purest Conduit or Spring water you can get putting some Aqua-vite therein to keep it from freezing stopping it close to keep the dust out; having thus done if you will use it at a table or bench, knock a tender-hook or Naile into the Seeling or Shelf, and with a tape or pack thread fasten it to the loope and hang it up; (but a round stick were better to hang it on, putting it into a poast or hole in the wall, that you may let it higher or lower at your pleasure in turning the stick.)

'Then behind your Glass set a candle lighted upon the table, and you shall have a glorious light through the glass and water for your purpose.'

The jewellers, engravers and blockmakers were the principal users depicted by Diderot in his famous 18th-century French encyclopaedia, but the adoption of these devices by the English lace schools about the same period seems to have been common enough for the stand bearing four such condensers with a candle in the middle to be associated with that particular craft. Four little girls of anything up to fifteen years old would work by the first lights from a single candle, but round them would be four more, or even eight more, catching the spilled light in similar, but far less effective condensers. Girls from five years old were taught in these schools and if they had not completed their allotted tasks before the light failed they were expected to stay behind and work by a light which, once the eye gets used to the conditions, was not good but by no means as bad as might be imagined.

All-glass lamps in which a float-wick burned in a bowl on top of a candlestick form of mount are also referred to by antique dealers as lace-makers lamps, but evidence to justify such a description has not been found. They were probably just elegant domestic lamps for the reasonably well-off household and it is not improbable that lace-making, as a gentlewoman's hobby, may have been done by their light.

Shipbuilding in the 17th century and later was occasionally done by night. In *The Autobiography of Phineas Pett* edited by W. G. Perrin, Naval Records Society, London, 1918, there is a reference to the building, in 1604, of a little ship for Prince Henry, son of James I. Work proceeded all night by torch and candlelights under a large

awning. In 1743, at Deptford Dockyard, candles were used 'for such workmen as can work by candle light two tydes each day'.[1]

The many-spouted grease lamp was known in the Netherlands at least as early as the 15th century and two centuries later they were common in Italy. A little later there is evidence that they had spread extensively to England and France. Among artists Joseph Wright, Zoffany and Elias Martin, in the late 18th century, all depicted

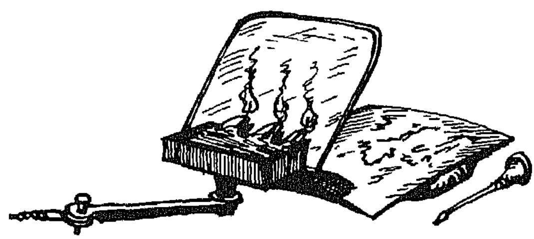


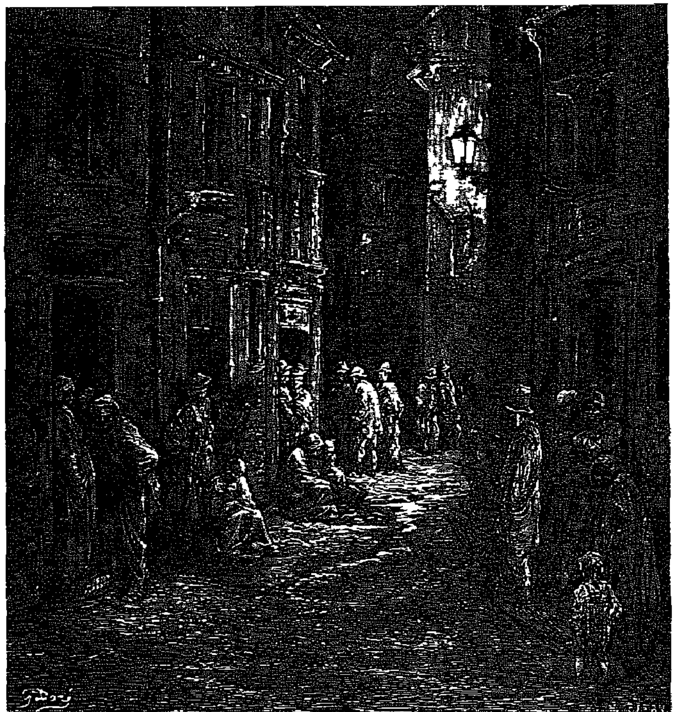
Fig. 35 Copper engraver's lamp with oiled paper screen. *Diderot.*

these star-shaped lamps in their studies of the life class at the Royal Academy in London; there was a conical smoke collector leading to a chimney above the multi-wicked lamp. This was doubtless desirable to take away the smoke of so many rather inaccessible wicks, but this refinement seems not to have been by any means general. For local lighting candles were used additionally. Diderot, in his *Encyclopaedia* of 1765–72, shows similar lamps, but with no chimney above, illuminating the pie-makers' and the tinsmiths' shops (Plate 18*b*).

In Diderot, apart from the water-condenser shown as part of the stock-in-trade of the jeweller, goldsmith, blockmaker and other fine craftsmen, the copper-plate engraver had another device intended to give a diffused light. John White, as early as 1651, described how 'oyled paper' was placed by some 'betwixt them and a candle, and this will cause a good light'. In Diderot the oiled paper is held in a frame interposed between a wall-mounted triple spout oil lamp and the engravers' work. Today, for the examination of sheet metal or for engraving metal a fully diffused light is just as important, and the modern worker could complain only in terms of relative brilliance if he were asked to use the light provided three centuries ago.

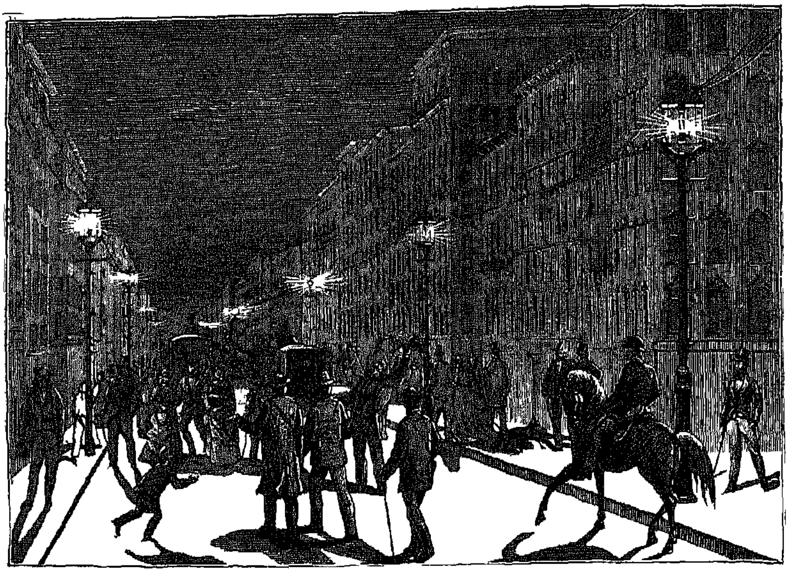
The engraver or block-maker fed the printing presses, but the press operators—if and when they worked after dark—could expect

[1] Deptford Yard letter book, ADM. 106/3306, Public Record Office, London.



Bluegate Fields, London, 1872 by Gustav Doré

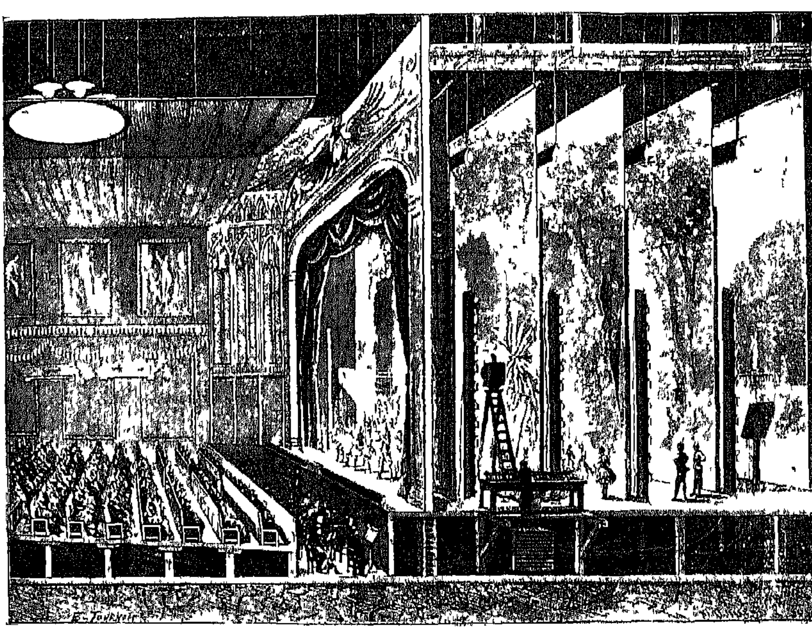
A ball at the Mansion House, London, 1872 by Gustav Doré



Brush Arc Lamps in New York City, 1881

Jablochkoff Candles at the Avenue de l'Opera, Paris, 1878

Swan Filament Lamps at Newcastle, England, 1881



Stage lighting by Edison lamps, 1883 from *The Electrical World*

Cooking, spinning and weaving by lamplight, 1658
from *Virgil* by John Ogilvy

far less lavish light as printing, relatively speaking, was rough work. On a printing press of about 1700 to be seen in the Science Museum, London, there are two socket candle holders on extendable iron frames to provide light for the printer and his assistant. Frames of this kind have a long history, as primitive types can be dated back to the 14th century. Candle holders adjustable vertically have also been made at least since the 15th–16th centuries. Wine tasters and wine bottlers still prefer candlelight by which to judge for colour and clarity and some adjustable candle holders of considerable age are still to be seen in wine cellars. (Plate 19). Egg testing, by comparison, is done with powerful electric lamps in spite of the fact that it is still referred to as 'candling'. A thick wick burning robustly in a spouted oil lamp was preferred to the cabdle a couple of centuries ago for this work.

An early working custom that it still preserved in modified form is the use of lights for fishing. In the Mediterranean today butane lamps in the sterns of motor-boats replace the fires in iron cressets that were hung out over the sterns of rowing-boats to attract the

Fig. 36. Decoying sea birds with light. *After Diderot.*

fish in earlier days (Plate 18*a*). In those days sea birds were caught in numbers for their oil and even for food. Tow and pitch was set alight in a barrel—*la baratte*—and the birds were netted as they flew in to investigate. A 17th-century Indian painting in the Victoria and Albert Museum shows the hunting of deer at night, using a torch and bell to attract them. These somewhat unsporting practices, akin

to dynamiting a fish pool, still survive. A powerful electric light known as the bulala lamp is worn like a miner's cap lamp. It picks out the reflections from the eyes of animals at night and the animals themselves usually stand still to be shot when they are startled by the light.

An 18th-century practice (that did not depend upon the properties of light as a lure) was common among the whaling fleets. To enable flensing to continue at night heavy strap-iron baskets were suspended outboard from the yard-arms. In these baskets bright fires of blubber were kept burning merrily.

As industrial pressure began to rise towards the middle of the 18th century the demand for satisfactory lights became urgent, but unsatisfied. Candles, tallow dips and simple oil lamps had to serve the factory and office as well as the home. The number of candles used was one of the accusations of extravagance against the office of the Navy Board, made by a dismissed clerk named Gilbert Wardlaw in 1699. The charges were refuted by Sir Cloudesley Shovel, for whom one of Pepys's trainees prepared the answers. One charge was that the purchase of 6,070 dozen candles in eleven years, at a cost of £1,628, was excessive. The number of working days when candles would be required was reckoned at 2,441 but the defence pointed out that 'there are very few nights, even in summer, that we do not burn candles at this office' and 'we have frequently wrought on Sundays during the late war'. There follows a detailed account of how the candles used varied from 25 per night in the Treasurer's ticket office to 18 for the Comptroller, 4 for the housekeeper and only 1 each for the messengers and purveyors. The total for seventy-five persons employed came to 137 per night at 4 to the lb. This makes the cost 1*s.* 10*d.* per lb. The wicks of candles supplied to the Navy in those times were specified as of 'best cotton'. From 1669 to 1692 the records refer only to good English tallow, London melted, at prices ranging from 4*s.* 2*d.* to 5*s.* 8*d.* a dozen. Some of these in 1688 were recorded as 'delivered at ye Navy Office'.

The Navy Board won the day. In the course of their defence they pointed out with some satisfaction that they burned less candles per head than some other offices, including their opponents at the Admiralty. They claimed that no office was 'shut up till nine or ten o'clock at night, and some continually staying till twelve, and past that hour sometimes'. Under 2 candles per head per night was deemed not unreasonable in the circumstances but the cost of tallow was near enough to that of wax to raise doubts, in retrospect, as to whether

longer-burning wax candles might not have cost less per night per person than the contemporary daily wages of two shipwrights.

The Argand burner of 1784 seemed to hold out great promise, but it was long before Argands were in significant numbers, and moreover the cost of maintaining the better light they gave was not inconsiderable. Industry wanted a cheap, bright, easily controlled light that did not require constant trimming and attention. With the advent of gas early in the 19th century it began to look as though the ideal medium were at hand; coal gas, as an illuminant, was described by Dr. Clayton in 1739 and was used by the engineer, William Murdock, piped through tubes as an illuminating medium, in 1792. It was Samuel Clegg, another first-class engineer, who used gas for lighting a factory in 1805. This was the cotton mill of Henry Lodge, Esq., near Halifax. He made other factory installations in 1807, 1809 and 1811. Murdock, in 1806, lit the cotton mills of Phillips & Lee near Manchester. These were described as 'one of the greatest cotton mills in the world'.

There was no public gas supply in those days. Each mill had to be supplied with its own retorts, gasholders and other equipment. The burners were simply iron tubes with holes pierced in them; and apart from the variable and often poor illuminating quality of gas produced by crude methods, the burners quickly corroded and, even when new, over-cooled the flame. The lights obtained were poor initially, by later standards, but after a while they were deplorable. Nevertheless, compared with the alternative illuminants of the time they were considered admirable.

Thus, in 1852, St. Paul's Cathedral in London had to be prepared for the state funeral of the Duke of Wellington. It was a tremendous occasion for which St. Paul's itself was blacked out and lit, in daytime, by innumerable gas jets from continuous pipes laid around the upper parts of the nave. The work of building stands for several thousand people had to continue day and night for weeks; the *Illustrated London News* of November 6th, 1852, described the scene thus:

'It has been found necessary to lay on gas upon both sides of the nave by the aid of which the men have been enabled to carry on their labours far into the night. When all these gas jets are lighted up, the interior of St. Paul's is hardly to be recognized, so strangely does the brilliant flame alter the character of the building and change its shadows.'

The lights for the workers were by no means as numerous as those

used at the actual ceremony. They consisted merely of a number of stand-pipes at intervals with flames emerging from holes pierced at their heads (Plate 20*a*).

At the time of the Crimean War of 1854–5 an urgent need developed for the provision of shallow-draught gunboats for use by the British Navy in operations inshore. Shipyards worked feverishly to supply these twin-screw steamships of about 300 tons burden and at the yard of John & Robert White at Cowes, Isle of Wight, a roof canopy was built over the unfinished hull and work went on by gaslight underneath.

It was not until 1858 that the Sugg steatite orifice gave a burner that not only prevented over-cooling of the flame but also remained effective for an almost unlimited period. Gas jets became a familiar feature in workshops, offices, shops and the home; elaborate globes and chandeliers distinguished many home, shop and even office installations compared with the stark simplicity of the usual factory burner.

From 1809 onwards there was a rapid growth of public gas supplies, but only in restricted urban areas. Unless the factory out of reach of such supplies were large enough to sustain the cost of installing and running its own gasworks it had to do as best it might with candles, or the crudest type of oil lamp usually burning tallow or fish oil with a wick of tow or rag. The better oil lamps required too much attention and were too expensive, both to buy and run, to compete with the candle once the self-snuffing plaited wick for stearine candles was introduced by Cambaceres in 1820. Before then the tallow candle had the crippling disadvantage of needing even more frequent attention. Rushlights, which dropped glowing 'chars', were out of the question if there was any inflammable material about. The paraffin lamp was a very different proposition as it needed only slight attention, such as turning the wick up a trifle now and then, and trimming very occasionally. But paraffin, in quantity and at reasonable price, became available only in the 1860s.

The sweated labour working long hours in poor conditions in the 19th century has been the theme of innumerable treatises on social history. We have been told of the insanitary conditions, the ignoring of safety measures, the provision of crude bunks for the young workers forced to sleep at the mills. The machines have been described and the food, clothing, wages, sins and virtues of the workers discussed. The one thing that has rarely been mentioned is the gloom in which they necessarily worked after sundown. Things were better from

the 1860s onwards, but compared with modern standards were appalling even then. It was the same in offices. It could hardly be otherwise for the only alternative was to burn a number of candles too great to be contemplated as an economic possibility.

It was the advent of electricity that made the most revolutionary changes in the lighting of work after dark. The arc lamp was demonstrated in a laboratory in 1810, but there were no machines capable of generating the electricity required. Surprisingly enough this was not sufficient to preclude entirely the use of the arc lamp as an aid to work by night. At great expense and difficulty there were one or two attempts to feed the arcs with great batteries of Bunsen cells. They were quite uneconomic. A quarry at Angers was arc-lit in 1863, very soon after primitive machines became available. The Guadarrama section of the Spanish Northern Railway was cut about the same time and it was estimated that arcs were in use for 10,000 hours in the process. It was said that the Paris Exhibition of 1878 could not have been opened on time had arc lamps not been used by the builders, but the efficiency and reliability of machines for generation, such as the Gramme and Siemens types, was by then greatly improved. A couple of years later M. Albaret of Liancourt devised a system of working on the harvest after dark by using lamps on high supports each of which was reputed to light effectively an area of 100 metres radius (Plate 20*b*). The portable steam-engines driving the dynamos could also be used as a source of power for the threshing machines. These agricultural applications were not widely employed, but for building work the arc lamp sprang into immediate favour and only in recent times have improved high-power light sources supplanted the arc.

For indoor applications the arc lamp was clearly unsuited to ordinary rooms, but for large, high-ceilinged areas it had much to commend it, in view of the defects of contemporary lighting methods. In France, M. Menier had his chocolate factories lit electrically in 1875, and both the Compagnie Chemin de Fer du Nord in 1876 and the P.L.M. Railway in 1879 lit their main parcels halls. In London and Glasgow, King's Cross and St. Enoch's stations followed suit shortly afterwards. Each of these installations involved the setting up of a generating station as there were no public supplies. The lighthouse projector works of Sautter & Lemonnier, another example of a high-roofed area, was among the pioneer factory installations in France.

The railway companies were so early in the arc lighting field that

it may be thought surprising there were not arcs on high towers to light up marshalling yards. The reason was probably one of economics. The attraction of brightly-lit main-line stations serving the travelling public would be worth considerable expense, both for installation and subsequent running costs, but gas still remained cheaper; also great numbers of low-set gas lamps were already installed at the shunting yards and it would have been a costly matter to scrap them. Later it proved economical to use the same installations converted to electric filament lamp lighting and although supplementary arc lamps were also employed they were not without disadvantages. High mounting heights could be a great disadvantage in murky weather and the trend even today is more towards large numbers of moderately powered mercury or sodium lamps at medium heights.

For factory work the arc also had many disadvantages. Even with the best of regulators its constancy left much to be desired and it threw the harshest of shadows. It had to be suspended well away from the work and was usually troublesome to get at when it required attention. The less efficient incandescent electric lamp might have sounded a better proposition were it not that the more cheaply run arc lamp nevertheless cost much more than gas lighting. Swan ran his own lamp factory in Newcastle by the light of Swan lamps in 1880–1 but as his 20-candlepower lamps, in their holders, cost 25*s.* each at first, and lasted only a very few hundred hours, the project was hardly economical. By 1883 the price had come down to 5*s.* a lamp, but even that made them suited more to lighting rich men's houses than factories. What was wanted was not only cheap, long-lasting lamps, but also cheap electricity such as could only be given from large power undertakings supplying a public demand. In this respect the Pearl Street power station built in New York by Edison in 1880–1 was a pioneer venture that it would be difficult to overpraise. It is true that most of the load was of Edison lamps installed in business offices rather than factories, but Edison was far-seeing enough to anticipate an electric motor load as well. In 1885 the average life of Edison lamps had risen to 1,000 hours. The first recorded motor load of his power company was 470 horse-power in 1889.

It was many years before incandescent filament lamps ousted the arc from more general favour. About 1885–6 the Brush Company, in the United States, ran many power stations supplying arc lamps. It was reckoned that a demand of more than 100 lights became economical and the tariff was £30 ($150) per lamp per year for factories, yards and similar private uses. The arcs were only switched on from

5–10 p.m. in winter, 7–10 p.m. in summer and 1–2 hours on Saturday. For a lamp burning all day 4*s.* ($) per day was charged, but this fell to 2*s.* 9*d.* (65 cents) per lamp if there were as many as 25 in circuit. The consumer was not charged for connection to the supply and night watchmen controlled the switching on and off for municipal authorities who were charged only 2*s.* 6*d.* to 3*s.* per lamp per night for street lighting (60–70 cents). A committee of the Society of Telegraph Engineers and Electricians, London (now the Institution of Electrical Engineers), made the following safety rule in 1882:

'Arc lamps should always be guarded by proper lanterns, to prevent danger from falling incandescent pieces of carbon and from ascending sparks. Their globes should be protected with wire netting.'

While this precaution was obviously very necessary in workshops, the globes quickly became soiled and maintenance was accordingly increased. Opaque globes, to reduce glare, cut off 60 per cent of the light emitted, and frosted globes 30 per cent. The Jablochkoff candle of 1878, which worked on alternating currents and needed neither regulator nor much attention, seemed at one time to be a great improvement on direct current arc lamps. Including street lighting there were 2,500 such candles working in Paris by 1880, but they proved both too noisy and too variable in tints and brilliancy for extensive workshop use.

Eventually the filament lamp came into its own due to a combination of improved designs and cheaper electric supplies. It is not possible to differentiate the workshop and office applications of filament lamps from those others that have already been described. One great advantage of the filament lamp over the arc was that it could be placed advantageously. The high-mounted arc threw harsh shadows that might come just at the danger area where good lighting was very desirable. Filament lamps can even be mounted inside the guards of power presses and other dangerous machines although it has long been a safety practice in such cases to transform the supply voltage to 12 volts in order to eliminate the possibility of serious electric shocks.

The Cooper-Hewitt mercury lamp of 1900 was employed to a limited extent in workshops and warehouses and particularly in photographic studios. As with the mercury and sodium lamps of 1932–4 the colour rendering was so very bad that it made little headway despite its efficiency. The high-pressure mercury lamp of 1939 was better in that respect, but the fluorescent tubular lamp of 1940

proved to be the answer in so many cases that other kinds of general workshop lighting, except where sharp shadows were required or colour quite unimportant, became rapidly obsolescent. Individual lighting is still to be recommended in selected positions.

A few general observations may be made in respect of workshop lighting. If the shapes of objects are to be estimated rapidly and easily, sharp contrasts in the illumination of the objects are desirable. Heavy shadows might seem to conform to this specification, but in practice they should always be avoided as the deepest shadows are simply areas almost wholly lacking in resolution. Contrasts can be obtained by lighting from several directions while still allowing the resolution of detail in every direction. Glare, whether direct or reflected, should be avoided even more than shadows, and it is for that reason that adjustable lamps, despite other disadvantages, became so popular for workshop use. The engraver, at least as early as 1651, avoided glare by using a diffusing medium between the light and the work. The same principle is used today.

The illumination level in a workshop should be high enough for the eye to follow the most rapid movement that may be expected. Three foot-candles may be enough in a foundry while 50-100 may not be too much for type-setting. There have been many attempts to relate output to changes in illumination intensity but there is no golden rule by which adequacy can be defined. In *The Hawthorne Experiment* by J. F. Roethlisberger (Harvard University Press, 1942), an account was given of the division into two parts of a workshop, one of which was made much brighter than the other. Output in the bright half went up very noticeably. Then the personnel was changed over and the output of those moved from the dim half went up in the same way. Unfortunately for theory, the output of those transferred back to dimness also went up slightly from the already increased standard. It was the change that did the trick. This is not to say that good lighting is not desirable, but it is a salutary example of the desirability of not jumping to conclusions. Some time ago it was suggested that the lace-makers' lamp was not good enough for making fine lace. But they did make fine lace by it in olden days and made good lace, earlier, by even poorer illumination; that does not mean that, with better lighting, they could not have made finer lace, and that more quickly. It was not for nothing that the lace-makers of Honiton in Devon worked, whenever they could, at the cottage door in the bright light of day.

Fig. 37. Mining, 16th century *from 'In re metallica' by Agricola, 1556.*

MINE LIGHTING

Mine lighting is a specialized application of illumination as there are so many conditions that may not be experienced in other fields. Coal mines may be potentially dangerous because of firedamp or explosive concentrations of coal dust. Naked flames and even the transitory incandescence remaining when a lamp is accidentally broken, must be avoided or controlled, and no electric sparking may be permitted in the free atmosphere. Metalliferous mines are usually, but by no means always, safe and some coal mines relatively so. In all mines there is the risk of roof falls and rough usage generally. Conditions at the working faces may be very different from those in the

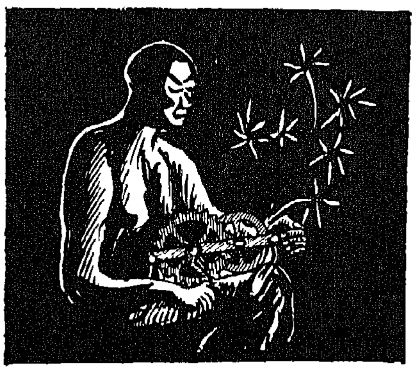


Fig. 38. Flint mill, 1760.

roads and at the shaft bottom. Reflection from untreated walls, and particularly at a coal face, is very small. The supply of air is limited, particularly in the case of accident, so that lamps should consume the minimum of oxygen and should generate no noxious fumes. They should, if possible, indicate when the air supply is becoming foul.

One of the earliest mine illuminants was the tallow candle with unguarded flame and susceptible to draughts. Strongly made spout wick oil lamps were found difficult to extinguish. The hurricane lamp (which is not a safety type) was introduced for mine working about 1880 and the acetylene lamp, also as a cap lamp, about 1905.

About 1760 one of the first 'safety' illuminants was the steel mill which superseded the use of the phosphorescent qualities of putrescent fish-skins at danger spots. The fairly cold sparks from a flint pressed on the surface of a steel disc rotated, through gearing, by a

boy whose sole task it was, were only capable of firing a limited range of the explosive mixtures that might be met down a mine. The light obtained was naturally very poor although better than the completely safe fish-skins which gave enough only to enable the miner and the women and children pulling the sledges on which the coal was piled to grope their way along the Stygian galleries near the working surface to the relative safety of the pit bottom where a naked flame might be risked without, at least, the inevitability of disaster. An oil lamp in which both air and the resultant gases passed through a water seal was invented by Dr. Clanny in 1813 and required the continuous services of a boy for pumping. In 1815 Sir Humphry Davy, the scientist who had first demonstrated the electric arc, showed that a cylinder of wire gauze around the flame of an oil lamp rendered it safe in most explosive mixtures of firedamp. This result was the culmination of a series of researches and for the first time safety was obtained together with a modest degree of illumination. The Davy lamp gave about half a candle-power. Various improvements contributing to greater safety, particularly in strong air currents, were devised by many experimenters, but the light itself became little better. In Britain the Miners' Lamps Committee, in their final report of 1924, were only able to recommend, as the minimum level acceptable from a miner's safety lamp, an output of 0·8 candle power. This is very much less than the light from an ordinary unshielded candle which, in the blackness of a pit, could not be regarded as good.

As early as August 1881, electric filament lamps were tried in mines of the Lanarkshire coalfield in Scotland. Sir Joseph Swan designed a fixture in which the bulb was immersed in water so that accidental breakage would immediately extinguish the filament, but he abandoned this in favour of a protective outer bulb of glass. In 1883. he also devised electric hand lamps supplied by battery. They gave no indication of the presence of firedamp and had therefore to be used in association with ordinary safety lamps. By 1923 over 300,000 electric hand lamps were in use in the mines of Britain. Special wiring, and protective switchgear and fittings have now been developed for mains lighting which has been permitted at the coal face itself since 1934. A great deal of work has been done on the problem of obtaining a satisfactorily disposed spread of illumination and it is now common practice to whitewash or cover with the whitish limestone powder used for stone-dusting (which prevents coal dust explosions) the roadways and the faces opposite the working faces in the mines.

The high-pressure mercury vapour lamp commercially introduced about 1934 has been found to be admirably suited to the illumination of the picking belts in a number of mines as it is much easier by its light to discriminate between some grades of coal and the stone or other unwanted adulterants.

In France, towards the end of the 19th century, a number of lamps were used consisting of a vacuum tube discharge fed from an ordinary Ruhmkorff coil. These were the forerunners of the fluorescent tubes from which most encouraging results are being obtained as a result of recent experiments in what may develop into the mine lighting of the future. Special fittings are required, not only to avoid the risk of firing an explosion, but also on account of the rough usage to be withstood. It will be some time before a stabilized technique can be developed. New methods of mine lighting should make miners' nystagmus, a disease of the eye caused by prolonged straining and the use of peripheral vision in the near dark, a thing of the past.

LIGHT FOR SURGERY AND MEDICINE

The conditions under which urgent medical tasks were undertaken in the old days were characterized at night by lack of light just as much as by lack of asepsis. Operations normally would be by day, but in war and childbirth that was not always possible. In war the mortality rate among major casualties was so high that a one-in-five chance of survival was accepted as nothing out of the ordinary. In childbirth the main hope was that nature would succeed with the minimum of assistance; but with the maximum number of probably unwashed, certainly unhygienic and mostly useless spectators. The more important the birth the greater the congregation. It was Marie Antoinette of France who managed to break this custom after a first accouchement at which she had to suffer a long labour in a room filled to capacity with a jostling, noisy crowd of courtiers and their ladies inspecting each other, and occasionally the scene, by the light of a great number of candles. In less exalted circles— well, the shepherd's lamp might serve just as well for his wife as for his sheep. Medically speaking the standards to be observed were little different.

It is therefore with some surprise that references are found to artificial lighting in the Hippocratic works of which the majority date to perhaps 400 B.C. The sixty or seventy works in this series survived in various ways as Arab, Jew and Christian equally venerated the Hippocratic oath. Many of the manuscripts may be no earlier

than 10th-century Byzantine copies of earlier writings. The 10-volume edition, *Oevres complètes d'Hippocrate,* by E. Littré, published in Paris between 1838 and 1861 has been taken as a source of reference in which the following passages occur.[1] In the ninth volume, *Du Médecin,* p. 207, it is observed that bright lights (daylight) should be used with caution because '*une grande clarité est inoffensive pour celui qui traite, mais elle ne l'est pas semblablement pour celui qui est traité*'. It is in the third volume (p. 175 *et seq.*) that the most extraordinary instructions are given for operations by lamplight. '*La lumière artificielle est a notre disposition. On se sect de chacune de deux façons, on en face, on de coté. De coté l'usage en est restreint, et le degré d'obliquité se determine sans difficulté. Quant a la lumière de face, il faut tourner, vers la plus vive des lumières presentés, si elle est la plus utile pour le cas actuel, la partie sur laquelle on opère.*'

Having exhorted the surgeon to turn the body to the best light, rather than move the lights about, it is then recommended that for certain operations where a facing light is to be preferred, care must be taken so to position it that the surgeon does not work in his own shadow.

An interesting sidelight on the treatment of epilepsy on p. 343 of Volume 7 is the inclusion among fumigants such as asphalt, sulphur, horn and aromatic oils for the treatment of cases of suffocation of the more easily obtained *meche de lampe.* A smoking lamp wick seems unusual physic, but earlier in the volume it is said to be good for nervous ailments of other kinds.

Special lighting for medical work is a relatively new art. Microscopes, for instance, could be lit only by ordinary oil lamps in which the flame was shielded by a metal chimney containing a glass window. In the 17th century such pioneer microscopists as Hooke used a large spherical water condenser and waited for sunshine to provide the source of light; by 1885, if not before, Swan's assistant Stearn was making tiny filament lamps supplied by a couple of Bunsen cells for microscope lighting. The filaments were 0·1 inches long and 0·01 inches diameter. Similar lamps were used, in 1886, in a laryngoscope which is virtually the same pattern as those in use today.

Perhaps more surprising is the rapidity with which new ideas in lighting were adapted to surgical examination; early experiments with incandescent platinum and iridium wires were made by John Marshall, 1851, Leroy d'Etrolles, 1853, Midcldorf, 1854, Broca, 1856

[1] There is a comparable work by H. Kuhlewein, *De Prognostici Hippocratici,* etc. Lipsiae, Nordhusae, 1876.

and, in 1867 by a Dr. Bruck of Breslau who made an instrument called the stomatoscope for lighting the buccal cavities. Although Dr. Millot, in France, claimed to have examined the stomachs of animals by such contrivances at the École Pratique de Paris, the heat of the incandescent wires combined with the inconstancy of the batteries used to supply current, made them quite impractical for ordinary uses. The use of water circulation to counteract the heat added just that element of cumbersomeness that the tiny devices were designed to obviate.

Between 1868 and 1872 Gaston Planté developed an apparatus fed by current from his secondary cells. This was used, in 1873, by a Dr. Onimus, for cauterization of the lachrymal gland of a number of patients. The incandescent wire first gave light to see by and then performed the operation. The bladder was explored by the light of a small Swan lamp by Sir Henry Thompson, and a water-cooled Swan lamp was used by a Mr. Payne to light the incision for abdominal operations. His method was greatly improved, about 1885, by Dr. Boisseau de Roche of Paris. He built a probe about 2 feet long and less than a quarter of an inch in diameter with a Swan lamp at the bottom above which was a prism and two convex lenses. The top of the probe contained another optical system through which to view the projected image of the cavity.

Later developments have been more in detail than fundamental, although the property of 'perspex' or 'Plexiglass' in carrying light round corners within itself has been made use of in recent years to keep the light source outside the patient. One recent improvement has been in operating theatre lamps which, while giving a high-intensity almost shadowless area of about 1 square foot at operating table height, are so designed optically that the surgeon's head is clear of the radiant heat area of the beam. In this way he can work without fear of generating unsterile perspiration.

LIGHT FOR WAR

As long as there are professional armies, warfare may be regarded as their work. For Joshua 'the sun stood still'. Those who believe in miracles may assume, literally, that the day was lengthened so that Joshua could complete his task; others will believe that he finished off the battle with such unexpected expedition that it seemed hardly possible that there still remained any daylight. Either way it is clear that at night a battle was broken off. Armies might possibly march

by the moon, but battles could hardly be fought by it. Gideon routed the Midianites (Judges Ch. VII) by having 300 picked men with 'torches' concealed in pitchers which they shattered at the moment of surprise.

Beacon fires at night, have given warnings of invaders since very early times. Homer, in the Iliad, Book XVIII (Ogilvy's translation, 1669) put it thus:

'. . . . . Then large fires at night
Gild darker waves, and make the ocean bright
That their allies may their condition know.
And man out ships against the pressing foe.'

Victories were celebrated by bonfires; in 1669 the Navy Board spent £40, quite officially, on these while John Higins in *England's Eliza* published in 1610, wrote:

'So here at home before her live's last date
Triumphant sounds of belles the stares did smite
And bright bon-fiers the darksome even did light
With gladsome flames for worthy victory.'

Right up to the present time the bonfire remains a symbol of victory or rejoicing.

Lights were used occasionally for signalling. Polybios, a Greco-Roman historian of the 2nd century B.C., recorded that messages could be passed across a river by a code that spelt out the letters according to which of two rows of three torches were held to one side or another of a screen. Jehan Bytharne, in 1543, described several types of light signal to be employed by the French Navy. The Chappe visible telegraph system introduced in France in 1792 spread all over Europe during the next fifty years and was worked to some extent at night by hanging lamps from the ends of the two rotatable signal-arms and along the centre pivoted cross-arm that carried them at its extremities. The heliograph sunlight signal is believed to date back to the 11th-century Arabs. Paraffin lamps in the late 1860s were quite commonly used for army signalling at night. About 1881 the French ironclad *Colbert* used two rows of five Swan lamps at the masthead and an electric switch panel below to signal orders with an ease and speed far greater than had been possible before.

It was not until the electric arc became practicable that artificial light began to occupy a serious position in warfare. It was during the improbably early year 1855, before there were any adequate

machines to generate current, that the French Navy employed a battery-fed arc at the focus of a parabolic reflector to illuminate the points of attack during the siege of Kinburn in the Baltic. This was in all probability an apparatus similar to that so effectively used a few years earlier by M. Duboscq at the Paris Opera. Similar apparatus was also available to the French Army in 1859 and the Italian Army in 1861, but the batteries were numerous, bulky and fragile, the materials for replenishing them a burden, and their deterioration under campaign conditions alarming. Added to that they generated noxious nitrous oxide in quantity. The Alliance magneto-electric generators, the only practical machines available at the time, weighed several tons in one lump, quite apart from a steam engine and boiler to drive the machine. For a campaign they were quite out of the question. It was therefore navies, French, British, Danish, Italian, Austrian and Russian that made most use of the electric light as they could easily carry all the apparatus aboard ship and generate the necessary current. Armies used the apparatus only occasionally. The siege of Paris, in 1870–1, was an obvious instance of a battle sufficiently static to merit installations by both sides. Those of the Germans were to direct the fire of their batteries and also to see what the French were doing at night, their arcs being fed by powerful machines. Within the beleaguered city there was only one Alliance machine available and that was used to supply a lamp at Montmartre with which they could signal optically to Argenteuil. All round the fortifications they had other arcs fed from Bunsen cells, but they were only just powerful enough to break the worst of the surrounding darkness.

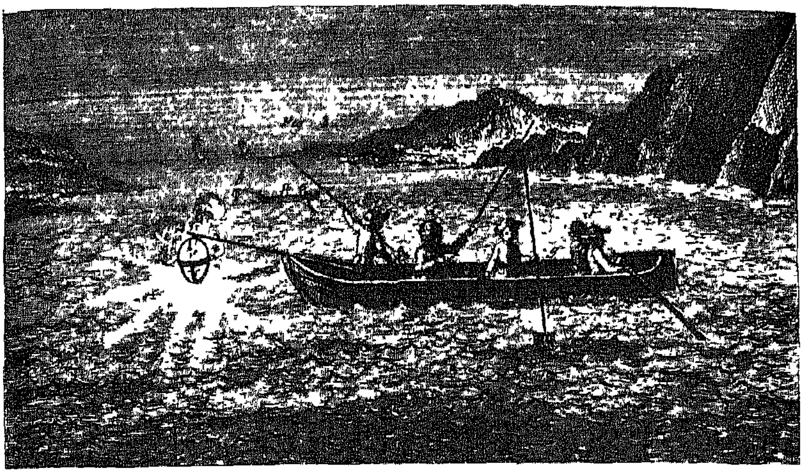
The Gramme machine, so much more powerful than the permanent magnet Alliance machines, was presented before the French Academy of Sciences in 1870 but could not be manufactured until after the war. About the same time, 1870–3, Siemens and Heffner von Alteneck produced an equivalent or better machine in Germany. The firm of Sautter & Lemonnier, who had long produced lighthouse lanterns in France, were employed to make searchlight projectors. Later, in 1877, a mirror of special form was designed by Colonel Mangin and became standard in the French Army. Mangin's projector was mounted on one carriage along with which was another containing a small vertical boiler, a 3-cylinder 'Brotherhood' steam-engine and a dynamo (Plate 21). This second carriage weighed nearly five tons at first, but much smaller equipments of lesser power were shortly afterwards made for field use. It was a large Mangin projector

High Society, candles

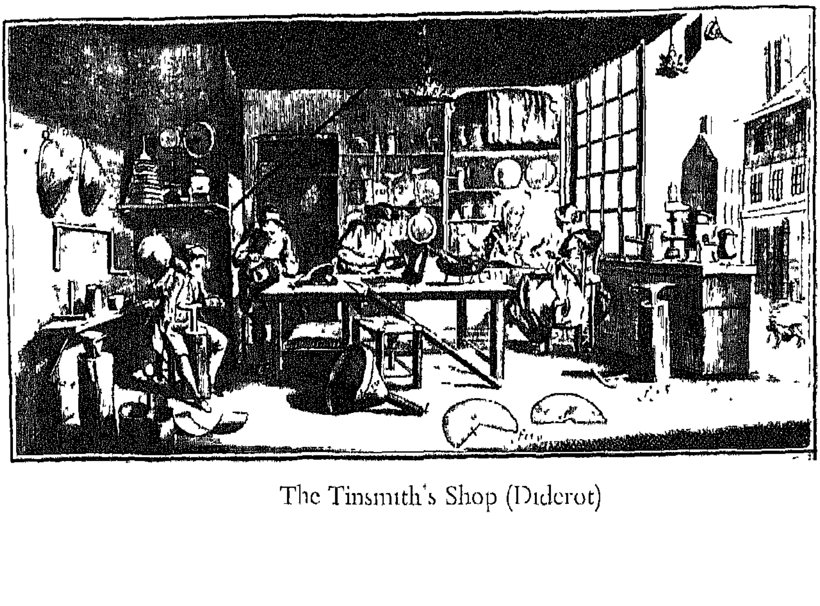
Gin Palace, gas

Cadgers Club, oil

Life in London, 1821 by I. R. and G. Cruickshank



Fishing with lights (Diderot)



The Tinsmith's Shop (Diderot)

which was used on board ship at the landing at Tabarka during the Tunisian war, but the smaller mobile ones could, it was said, be drawn by one horse. There was no practical alternative to horse transport in those days. It was even suggested that the smaller equipment might be taken to pieces and carried on mule-back in mountainous country.

By 1881 Sautter & Lemonnier had delivered 40 of the largest Mangin projectors (at 30,000 francs each) to the French Government, but only ten of these were for use in land fortresses. The rest were installed principally around the coasts. Chatham in England; Pola in Austria; Cronstadt in Russia—all had similar lights, and during the Turco-Russian War Odessa, Sebastopol and Orchakow were similarly protected from surprise attack. A carrying power up to 6 kilometres was claimed for the larger projectors and up to 3 kilometres for the smallest field type.

With the advent of radar during the 1939-45 war the searchlight lost much of its attraction for combat usage, as it inevitably gave away its own position. Nevertheless in the later months of 1940 an airborne searchlight developed in Britain was worked off secondary batteries and took 1,400 amps. at 100 volts. Positive carbons were $1\frac{1}{2}$ inches in diameter and the maximum amount of use before descending to re-charge and re-fit was four periods of 30 seconds. From this equipment a monster ground-operated light was developed in which a positive carbon $2\frac{1}{2}$ inches in diameter and about 2 feet long was wholly consumed in eight minutes. The light was air and water-cooled, took 4,000 amps. (600 kilowatts) and had a peak beam intensity of 2,700,000,000 candles with a mirror 10 feet in diameter. It was claimed that four such lights, strategically placed, could cover the requirements of the whole of the night sky above London and that, with a 6° beam, no aircraft, once caught in the beam, could dodge away. Mercury vapour discharge lamps were used in airborne naval searchlights of 1 kilowatt rating in the anti-submarine patrols. In all these cases it was intended that the target should roughly be spotted by radar and the light used for the kill. Radar has since improved so greatly in accuracy that searchlight assistance is now hardly necessary.

SHOP LIGHTING

The lighting of shops, up to recent times, cannot have differed greatly from the lighting of houses. In Greek and Roman times business was to some extent done at night and excavations of market-places have revealed considerable numbers of lamps in the shops.

At the Agora in Athens, where lamps by the hundred have been dug up, there was one large specimen of 1st–2nd century B.C. that was about 10 inches in diameter by 6 inches high with a wick spout for a wick between 1 inch and 1½ inches in diameter. The Agora was the centre of political, commercial and social life in Athens for eight or nine centuries so that the numbers of Greek and Roman lamps found at a site six acres in extent with temples, concert hall

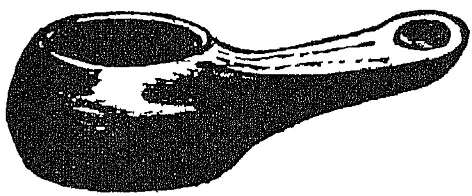


Fig. 39. Large lamp from the Agora, Athens.

and Council House, does not necessarily imply any commercial activity on a great scale at night. Results from other market centres, such as that of Corinth, do make it clear that there was at least some trading after dark.

It may be taken for granted that most shopkeepers would be prudent enough to put up the shutters and close their premises at dusk in the days when bands of robbers were roaming almost unchecked at night through main cities such as London and Paris. The gentleman with his escort might go abroad to knock up the merchant from whom he required a purchase. In that event the merchant, living over his shop, would doubtless identify his customer from a first-floor window before descending to admit him. Once inside the shop, possibly with the bolts again shot home, the customer would make known his wants and the shopkeeper would find his wares and display them by the light of candles or oil lamps.

In those days window displays were hardly necessary at night. A lantern might be hung out to illuminate the sign of the merchant's trade over the shop door, but this would be all. Window displays would not only be too great a temptation to the thugs, but the small panes of glass, that by their size denied them entry, at the same time made effective display more difficult; add to this the trouble of snuffing candles or trimming lamp wicks at frequent intervals, the difficulty of getting a bright overall illumination, the smoke

that would quickly soil the goods and the danger of fire. The unattractiveness to the average shopkeeper of a window display at night becomes too obvious for further elaboration.

The Argand burner of 1784 came in at a time when the streets were becoming more orderly and more people ventured out at night. These burners were much more powerful, equivalent to perhaps a dozen candles, and required neither frequent attention nor watching for smoke if they were reasonably well trimmed. Nevertheless, although many shops began to stay open to eight or nine o'clock at night window displays were the exception. The advent of gas, from about 1812 onwards in London, gave the shopkeeper a more adaptable lighting medium still, of which he was not slow to take advantage. Gas supplies were of uncertain quality and burners apt to deteriorate badly, but the Sugg steatite orifice burner of 1858 at least removed the second difficulty. The gas jet became a common feature in the shop windows, and in the shops themselves, but gas supplies were far from perfect. An enclosed gas light was patented by a Mr. Dix in 1852 with the object of remedying 'one of the greatest difficulties and objections connected with the use of gas in our shops and private dwellings, viz. the entire removal of all the deleterious products of combustion, the sulphurous and carbonic acids, so detrimental to plate, paintings, books, silk etc, and at the same time so injurious to the health of those inhaling the vitiated air emitted by all other kindred and ordinary methods of illumination'[1]

Mr. Dix ran tubes through the ceiling to introduce air and to take away hot gases which he cooled by a water circulation system. The Siemens regenerative gas burner of 1879 was far more successful, the hot outgoing gases pre-heating the incoming gas supply to the burner. These lamps, for which highly decorated porcelain bodies were made according to the taste of the time, actually aided ventilation when proper provision was made for leading away the hot gases. They became very popular for shop use, but not always with such provision.

Electric lighting of shops seems to have begun with the arc lamp. A 'luminous ceiling' made by installing arcs and reflectors above a ground glass centre, was installed at the Magasins du Louvre in Paris by Mr. Fontaine in 1877. A four-light Brush arc lamp installation was made at the Continental Clothing House, Boston, Mass., in the following year. In the next decade filament lamps, more manageable

[1] *Manchester Guardian*, December 24th, 1853.

if less spectacular, appeared. A decade after that, in the 1890s, the incandescent gas mantle enabled gas to regain a hold it had been losing rapidly to electric competition.

Both arc lamps and high-powered gas lights were unwieldy and generated considerable heat. Early in the 20th century and, indeed, for a score or more years after, it was not uncommon to find such lights placed *outside* shop windows. The theory, apart from convenience, was that the light attracted customers, and this may well have been so. It did not, however, provide the best means of interesting the attracted customer in the display behind the window. The lamps outside gave awkward reflections from the window glass and deep, confusing shadows from the goods inside. In *The Illuminating Engineer* of October, 1914, it was said that 'quite a number of shops are said to have already adopted shades throwing light into the window, but screening the lamps from view. Military requirements are bringing about a change which illuminating engineers have long recommended!' Another common practice of the same period was to line the window-frames with naked light bulbs. The glare from these made a focus of light to draw the eye from afar, but the attraction decreased as the eye approached near enough to be so dazzled that it became difficult to see the goods displayed behind the barrage of incandescence. The 'Linolite' lamp—in 8 in. or 10 in. tube containing a long carbon filament—was brought in in 1901–2. Housed in special fittings these lamps were easily concealed behind show-case mouldings.

The control of light for shop-window display had reached an advanced stage of understanding by 1913; it made great strides between 1920 and 1930 when principles that had been clearly recognized by technicians, but were used only exceptionally before (except for the larger stores) were adopted on a rapidly increasing scale. The silvered reflector for general high-intensity lighting and the spotlight for picking out the items upon which emphasis was to be laid, both leaped into popularity. As early as 1914, 65 per cent of stores in U.S.A. used some form of light-control. Batteries of reflectors at ceiling height were concealed by pelmets and cross valances. It soon became axiomatic that the lights should not be seen and that they should be directed on to the goods rather than waste a considerable proportion of their substance on the pavement outside the shop. It was also realized that the hard direct light that would put sparkle into a jeweller's shop window did not give the best effect in a drapery store displaying folds of delicately patterned cloths. The spotlight was used to add life and shadow to a display shown under a high ambient level of

illumination in which shadows were weak owing to the many directions from which the light of overlapping beams built up the overall illumination. Nevertheless there are still examples today of practices that were being roundly condemned in *The Illuminating Engineer* of 1913.

Mercury and sodium lamps were hardly suitable for shop use, but the fluorescent tubes of 1940 were adapted to a considerable extent in U.S.A. long before they became available to the European public in the post-war years from 1946 onwards. The low intrinsic brightness of these tubes tempted many shopkeepers into repeating the earlier mistake of allowing the light sources to be visible; but as the technique of usage became stabilized it was appreciated that it was just as desirable to conceal fluorescent sources as any other. Their excellent colour-rendering properties and the ease and economy with which high-intensity coverage could be obtained enabled them to achieve popularity with great rapidity. It was, however, soon realized that their light was virtually shadowless and supplementation by spotlights became obligatory for most applications. The tungsten filament spotlight was also found to add cheerfulness to the effect.

For both general light and shop-window lighting there has been a limited application of cold cathode high-voltage fluorescent lighting. Three lines of such light—red, blue and green—give an integrated whit light, or a single tube with an appropriate phosphor coating can give the same effect. Colour effects can be obtained from other combinations. These lamps are very long-lived (10,000 hours or more) and highly economical to run, but the dangerous voltages at which they work (10,000 or more volts) confine their use to positions inaccessible to the public and their maintenance should be left to electricians.

The subjects of projectors, reflectors, egg-crate louvred ceilings and so on are the province of the illumination engineer whose services are now becoming almost essential for the economical presentation of the shopkeepers' wares in a manner likely to catch the attention of the public. Like advertising in general, there is a sneaking feeling, even among practitioners, that it is becoming too great a burden and may even be well past the peak dictated by the law of decreasing returns. Unfortunately the law acts only in a general sense while competition is particular. The individual competitor cannot afford a less striking display than his rival, and in the end the cost must be passed on to the public. Perhaps the most consoling feature, as far as

lighting is concerned, may be summed up in the words of Edna St. Vincent Millay:

'My candle burns at both ends
It will not last the night
But Ah! my foes and Oh! my friends,
It gives a lovely light!'

Also, so excellently combined may be the qualities of modern electric lights of various kinds that the competent lighting engineer can get these high-intensity effects without the generation of excessive heat.

LIGHT FOR TIMEKEEPING

People who work require to know how the time is passing. The chapter on 'Light for Work' is probably as good as any in which to insert a few notes.

In the 9th century King Alfred, in England, introduced the timekeeping candle, of which six weighed as much as 72 silver pennies and burned for twenty-four hours. A thin beeswax candle weighing $\frac{2}{5}$ of an ounce does, in fact, burn for about four hours. In the 11th century the Arabs enclosed a candle in a six-sided container, each side graduated in hours. Every two months during the year the time was told from a different face, for the length of an hour, as in ancient Rome, varied with the seasons of the year. The time was told from the level to which the candle had burnt down. Oil lamps clearly provided a similar means of telling the time if, in a transparent reservoir, the level of the oil could be gauged. This is simply a variation on the Egyptian water-clock in which time was told by the water-level in a jar containing a tiny escape hole at the bottom. The rate of burning away of oil obviously depends to some extent on both oil and wick, so that timekeeping lamps were of a very rough order of exactitude. They were practically unknown until the 18th century A.D.

For actual working time the miners in the Cornish tin mines and other safe pits carried a candle set in their caps. The candle was of such a size to last the length of a shift and, while it was used to illuminate the work it also served to indicate when the working time had elapsed.

The candle auction must be mentioned. The last to bid before a stub of candle flickered out gained the lot, and for centuries Church acres were auctioned in this way in England. So were the King's farms and the ships of the British Navy when they were past

further use in war. Cotgrave, in his French-English Dictionary of 1611 says of '*À la Chandelle Esteincte*' that it means 'Too late when a thing is past recovery; after all is gone, or the business is done; this phrase and the former'—(*À la Chandelle Allumée*)—'seeme derived from out-ropes; wherein after the first offers made a candle

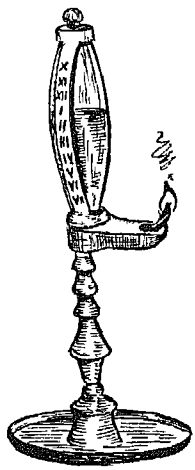


Fig. 40. Timekeeping lamp, 18th century.

is lighted at the bidding of more; aftere which, that being put out, another is also lighted, when a third part more is bidden and when twice as much, another, which once put out the thing is instantly delivered over'.

This system of auctioning, apparently known in France as well as England, may have favoured the vendor, for the entry under '*Se Brusler à la Chandelle*' in the same work is 'sayd of one that gives so much for a farme of the King's (which is let by out-crie, who will give most, while three pound of wax candles last lighted) that he loses verie much by it'; this phrase is also taken otherwise as in that which follows:

'*Il se vient brusler à la chandelle*. The light he hath received ruines him; or that which might have directed comes to ruine him, also, he hath disclosed his own KNAVERIE, he hath betrayed himself.'

Pepys, on September 3rd, 1662, described the auctioning of three ships by the candle:

'After dinner, by water to the office, and there we met and sold

the Weymouth, Successe and Fellowship hulks, where pleasant to see how backward men are at first to bid; and yet when the candle is going out how they bawl and dispute afterwards who bid the most first. And here I observed one man cunninger than the rest that was sure to bid the last man and to carry it; and inquiring the reason he told me that just as the flame goes out the smoke descends, which is a thing I never observed before and by that he do know the instant when to bid last, which is very pretty.'

The 18th-century press carried many advertisements for such sales. Thus in Williamson's *Advertiser* of Liverpool, 20.8.1756; 'To be sold by the candle at 1 o'clock noon at R. Williamson's shop, twelve pipes of raisin wine, two boxes of bottled cyder, six sacks of flour, three negro men, two negro women, two negro boys and one negro girl.' This type of auction was continued to quite recent times in some areas. Even now (1955) Church acre auctions are still held this way in five villages in Britain; but at Aldermaston in Berkshire the last bid is determined by sticking a pin into the candle and carrying on until it falls out. The vicar inserts the pin and declares the purchase, and bids are very slow right up to the last minute or so. The two-acre field fetched 255 shillings in 1950, but only 162 shillings in 1953. In the flurry of the final seconds large variations are possible regardless of current economic trends. No doubt some of the successful bidders still '*se brusler à la chandelle*'. The more leisurely habits of the citizens of North Curry, Somerset, who drank at the expense of the Reeve on his feast day until 'two candles of one pound weight' were burnt out, were perhaps to be preferred.

LIGHTING OF ART GALLERIES

This is one of the applications of lighting that was virtually unheard of before gaslight and made little progress until electric filament lamps were invented. It is hardly surprising that this should be the case as the 16th century '*à la chandelle la chevre semble demoiselle*'—a goat seems like a gentlewoman by candlelight—expresses admirably the extent to which gloom after dark was customary. A commission headed by Professor Faraday reported to the Lords of the Privy Council on Education in 1859 on 'Lighting Picture Galleries by Gas' in the following terms:

'There is nothing innate in coal gas which renders its application to the illumination of picture galleries objectionable. Its light, though

not so white as that of the sun, is equally harmless; its radiant heat may be rendered innocuous by placing a sufficient distance between the gas jets and the pictures, while the heat of combustion may be rendered eminently serviceable in promoting ventilation.'

So far, so good; but the committee realized that not all coal gas had been freed from sulphuretted hydrogen and all coal gas produced sulphuric acid on combustion which, said the committee with emphasis, meant that the products of combustion should be kept effectively away from the pictures. This, after experiment, they claimed could be done, but there is little evidence that galleries were lit by gas on any substantial scale.

The electric filament lamp of 1879 seemed to give promise with which the earlier arc lamps, with their very crude colour renderings, could not compete. Nevertheless a visitor to the art gallery in New York City lit somewhat optimistically by a central cluster of Edison electric lamps in 1880 (Plate *9b*) would see colours by a light that was too dim and too pronounced in its intensity at the red end of the spectrum. The most powerful incandescent filament lamps of later years all suffered from this colour defect and many were the devices employed to correct it. One of the most ingenious was the holophane reflector consisting of an enamelled surface, colour spotted, in which blues predominated. In America even today there is one leading practitioner who uses three spotlights, red, blue and green, to light each picture. This method was being used by Luckiesh in Schenectady in 1913. With variable resistances and bulbs of differing powers in each circuit a light is obtained that brings out exactly the effect it is believed that the artist intended. Each picture is lit differently and it is not improbable that each art critic differs from every other in assessing whether the balance is or is not correct.

A number of picture galleries have been lit by means of tungsten filament projector lamps carried above a false ceiling louvred so that the light shines on the pictures themselves but is cut off from the eyes of the visitor (unless he looks vertically upwards or otherwise contorts himself). The advantage of a louvred ceiling is that it is also useful in daylight if the projector lamps are so positioned that they do not cast unwanted shadows. This is not difficult to arrange. Colour filters to cut out some of the excess red of the tungsten light have been used. They reduce the efficiency of the lamps but increase that of presentation.

Fluorescent lamps have been used in some important galleries,

including the National Gallery, London, where they are housed behind a louvred sub-ceiling and are provided with reflectors designed so that an even illumination is given over the area on which the pictures are hung. Under these lights blues come up well—some may even say too well—but as all art is a matter of interpretation a fluorescent lamp approximating to daylight of a fairly average specification is probably as good a compromise as can be obtained for a gallery serving the public.

Finally it is the considered opinion of those who have made quantitative tests that fluorescent lighting, or indeed other kinds of electric lighting, is harmless to pictures and may be very much less harmful to fugitive colours, such as those in some fabrics, than north daylight. The very small quantity of short-wave ultra-violet light emitted by fluorescent lamps is not of any consequence as regards fading. In many cases the danger to fabrics is greater from the generation of hydrogen peroxide by photo-chemical action in which visible radiation is the stimulating factor. In other cases rhythmic changes in temperature, which can be avoided in an artificially-lit gallery, may be the principal source of damage to a work of art. Fugitive colours will fade away in time whatever the conditions. For stable pigments the fluorescent lamp or the tungsten lamp, properly controlled at reasonable intensities, is far gentler than daylight and practically incapable of harm.

CHAPTER VI

Light in Worship and Superstition

THE Lascaux caves in France, with astonishing wall paintings made 15,000 years ago, are believed to have been the scene of ceremonial initiation of young hunters to the arts of the chase. It is clear that they were not dwelling-places. There are over seventy known prehistoric decorated caves in France and Spain and the same is probably true for all of them. At the Lascaux caves a hundred stone lamps were found far from the entrance.

In ancient Egypt, and many other parts of the world, the sun was made an object of worship; the lamp, giving its feeble light at night, shared in the distinction between light, denoting good, and darkness, denoting evil. The Sumerians, nearly 5,000 years ago, made lamps with prophylactic markings to protect them from evil spirits. The Babylonians a millennium later had 'Shamash'—the sun—as one of the greatest names in their Pantheon like the Egyptian 'Ra'. They went further than the Egyptians by including the moon also as one of their Gods.

The Brahmin had a God of Fire, the seven-armed Agni, which may have some remote relationship to the use of seven-branched lamp-holders by the Jews before the ark of the covenant (Exodus, Leviticus, Numbers). Fire, stolen from the Gods by Prometheus (or the Norse Loki, both of whom were given terrible punishments for their temerity) was never quite in the same category as lamplight. There was a greater element of terror and cruelty in its worship. The Aztec sun-worshippers may have equalled in this respect the worshippers of Moloch, but more generally the sun was regarded as an influence for good and fire as a potential evil. The fires of the Christian hell are in keeping with this tradition, although there is a very extensive mythology based on fire-worship in which parallels to the worship of light can be found. The idea of the perpetual fires of the Prytaneum in Attica or the Vestal virgins in Rome is paralleled

by the perpetual lamps of the Christian churches; of Toc H and the tomb of the unknown soldier at Westminster Abbey, the Arc de Triomphe and elsewhere; and the sacred natural gas flames at Muktinath in Nepal today. Flames lit from sacred flames had their own mystical significance, and still have; the Easter ceremonies at the Church of the Holy Sepulchre (Orthodox Greek) and the revival of the Olympic torch ceremony at the Olympic Games are two out of many modern survivals from a common ancient belief.

It would be easy to loiter in these fascinating by-ways. The connection between fires and lights and fertility rites would alone provide material for a folk-lore monograph; but it is not folk-lore with which this publication is primarily concerned. Light, by association with the sun or with fire became a normal adjunct of religion. Rituals developed and certain festivities became associated with lighting on an unusual scale. Thus, at festival times in Babylon great stone bowls containing perhaps a hundredweight of wax or fat were set in the streets to burn, with thick rope wicks. Herodotus wrote of the Feast of Lamps, or Lychnokaie, at Sais in Egypt (about 450 B.C.) and expressed surprise at the great number of lamps employed. He also recorded, although he is possibly less reliable than many other historians, that Mycerinus, a ruler of Egypt four millenia ago, was told by the oracle that he had only six years to live. He therefore, according to Rawlinson's translation 'had lamps prepared which he lighted every day at eventime and feasted and enjoyed himself both by day and night, moving about in the marsh country and the woods and visiting all the places he had heard were agreeable sojourns. His wish was to prove the oracle false by turning nights into days and so living twelve years in the space of six. Ovid (43 B.C.–A.D. 18) described how at celebrations in honour of the Goddess Palleas the crowds passed three times around great fires of straw. Fertility rites were associated with the Roman Lupercalia, or feast of lamps, which became so notorious for the licentiousness that attended the consequent revels that Pope Gelasius (A.D. 492–96), unable to persuade the faithful to ignore the festival entirely, converted it for the Christian church into the feast of Candlemas which is still observed on February 2nd each year. The lamps that Juvenal (1st century A.D.) described as set in the windows of houses on feast days were probably for burning incense or other perfumes rather than for lighting.

In the Christian church many existing customs are very old indeed. The Council of Carthage in A.D. 398 decreed that the acolyte should receive a candlestick and a wax taper at the hands of the archdeacon

to remind him that his function was to light the candles in the church. The great Paschal candles for the Easter ceremonies were already in being, having been introduced half a century before. The present custom of lighting candles on the altars in Roman Catholic churches for the services is not so old, dating only to the 10th century. Pope Leo IV, in the middle of the 9th century, prohibited the use of candles on altars and they were always held by servitors (or on side tables in the Greek church). On the other hand the perpetual lamp before the altar can be traced back at least to St. Paulinus who became Bishop of Nola in A.D. 409. In describing such a lamp he also remarked how a wick of linen or waxed paper could be anchored by a small piece of lead in the water on which the oil of the lamp could be floated. Some of these sanctuary lamps later became very elaborate and valuable. In the 8th century Pope Adrian I installed one in St. Peter's in Rome in the form of a cross bearing as many as 1,370 lights. It is not unlikely that a perpetual light was kept before Christian altars from the earliest days of the religion, as the Romans were accustomed to burning lamps perpetually before the altars of their household gods. There is an obvious reason for the custom in the avoidance of accidental desecration in the dark. The votive candle in Roman Catholic churches is yet another example of providing that little extra light so desirable to attract others safely to the altar or shrine. The burning of the candle was to give light. No particular virtue lay in the actual combustion. The church might make a profit on the sale, but it was the prayer, not the candle, that justified the votive custom; but the candle made it easier for the custom to be followed.

The lighting of churches became a charge on the faithful and there is no doubt that it was quite a heavy charge. In the year 505 the Governor of Odessa made the churches and monasteries give up part of the oil they received for this purpose, so that he could light the streets of the town. This was exceptional. Normally the churches demanded and received the best. They usually burned only wax candles of the whitest wax; in 14th-century France, for instance, this was 3 sous 4 deniers a lb. plus 10 deniers for making up into candles, while inferior wax at 3 sous per lb. could be made into flambeaux for 5 deniers only. The votive candles bought by members of the congregation to burn before effigies of saints could, however, be of second-grade materials. Even today the Roman Catholic Church specifies that candles for its altars must contain at least 65 per cent of wax that the parent bee has produced—although paraffin wax is,

of course, very much cheaper. One exception to the demand for white wax in earlier days was for funerals and masses for the dead at which unbleached yellow wax was regarded as a sign of mourning.

A curiously mixed-up symbolism derived from the beeswax candle, partly because in pagan Rome and Sicily there had been a mythology associated with the bee that had never wholly been discarded. The bee was regarded as a virgin producer of offspring and the one king bee in the hive (now known as the queen) was likened to the kings and later popes and bishops. Lay brothers in monasteries were compared with the drones and if they were scourged for their own good now and then it was a parallel with the slaughter of the drones of the hive. The mother bee *apis mater* was wrongly supposed to produce the wax. Candles symbolized the virgin body of Christ and their light the divine light. The virginity of the bee gave it a special place in symbolism, and in the candle for which the bee provided wax the wick was symbolically linked with the soul. The ancients, mystified by the complex economy and habits of the hive, regarded the bees as divine. When beeswax candles, probably for quite utilitarian reasons, appeared on Christian altars this mythology was translated, but not ignored.

There are many records of bequests for the provision of wax candles to the Church. In 1487 John Bartelott of Chichester willed to the Church of St. Peter the Less 'a candle weighting 8 lb.' and also 'a torch weighing 12 lb.' which was presumably used for the lying-in-state. Another Chichester man, Thomas Bachelor, bequeathed 'four 4 lb. wax candles to burn about the hearse at my exiquies' in the same year.[1] At the burial of William Caxton at St. Margaret's, Westminster, in 1491 the churchwardens entered in the accounts: 'item at bureyenge of Willm. Caxton for iiij torches, vjs viijd.' At 1*s*. 8*d*. each in those days the father of English printing could at least claim his burial torches were on no niggardly standard.

An extraordinary instance of the votive candle is provided by a custom in the 14th and 15th centuries in France. At times of war or pestilence a town might subscribe to provide a long taper to burn in the principal church as a protection against disaster. The taper was made by measuring a fibre wick the length of the perimeter of the town and winding it, dipped in wax, round a large wooden drum. The wick might be several miles long and the taper would thus burn

[1] See 'Some Chichester Wills, 1483–1504' by W. D. Peckham, *Sussex Archaeological Collections*, Vol. 87, 1948.

for a couple of months or more. Paris, in 1357, offered to the Virgin to mark a reconciliation with the Dauphin, a taper '*longeur du tour de la ville de Paris, si comme l'on disoit, pour ardoir jour et nuit sans cesse*'. At Bethune, during a plague in 1480, a taper 1,705 toises (about 3,500 yards) long contained 160 lb. of wax while at Bourges during a pestilence nineteen years later 466 lb. of wax was similarly consumed. This same peculiar votive custom was extended to the case of a sick animal such as a cow by measuring off a taper that would just encircle its body, and taking it to the church to burn for the animal's recovery.

Candlemas Day is also the Feast of the Purification of the Virgin. This association of light and purification had had less pleasant results. Medieval and, indeed, later theologians and scholars have often tended towards excessive zeal in following up an idea with inexorable if dubious logic. In the old myths Hercules, Croesus and Empedocles assumed the character of Gods by being burnt alive either on pyres or in the craters of volcanoes. The Romans burnt their dead at night, and the Brahmins by day, in order to make them fit for meeting the Gods. The idea of fire and purification was carried on into Christianity by the feast of Candlemas; what, then, could be simpler logic than the burning to purify their souls of heretics? A wax taper, symbolizing the light they had lost but hoped to regain, was put into their hands as they were marched through the streets to their doom.

On the arrival of twelve Franciscan friars in Mexico in 1524 it was said by Prescott in his *Conquest of Mexico* that 'processions were formed of natives bearing wax tapers in their hands'—presumably to denote the rescue of those Aztecs from heresy. The Aztecs themselves can have found nothing strange in the idea as in their own pagan ceremonies they frequently carried lights, the symbolism of which was not greatly different.

Parallel to this curious idea of purification by fire was the *fax nuptialis*, or burning taper, as a symbol of marriage. It was usual to light the newly-wed couple to the bridal couch; and in many cases in medieval times the tapers were held until the marriage had been consummated to the satisfaction of the audience, particularly on occasions when the bridal pair were of high rank. The hymenical torch was known to Homer, in 800 B.C.; in the Iliad, Book XVIII, he says (Ogilvy's translation, 1669):

'Next he two Cities to the life exprest
In one were Nuptials and a golden feast

Brides from the Wedding-Houses in great state
With torches grace the streets, their Bride-grooms wait,
Youths dance to cornets or the softer lyre
Grave matrons standing at their doors admire.'

This was Ogilvy's translation of 1669: a translation of 1805 mentions the torches only by inference:

'Here sacred pomp and genial feast delight
And solemn dance and hymenical rite.'

Shakespeare, in *Coriolanus,* i. 6, says:

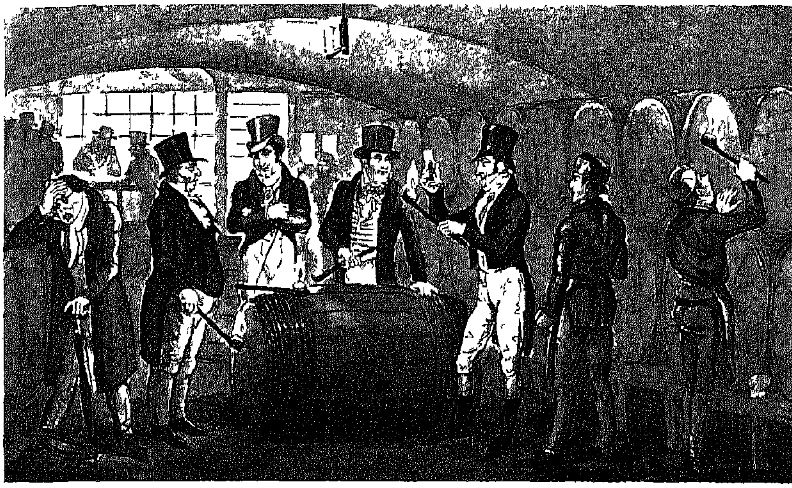
'As merry as when our nuptial day was done
And tapers burned to bedward.'

And an even clearer reference is given by John Milton in the *Allegro*:

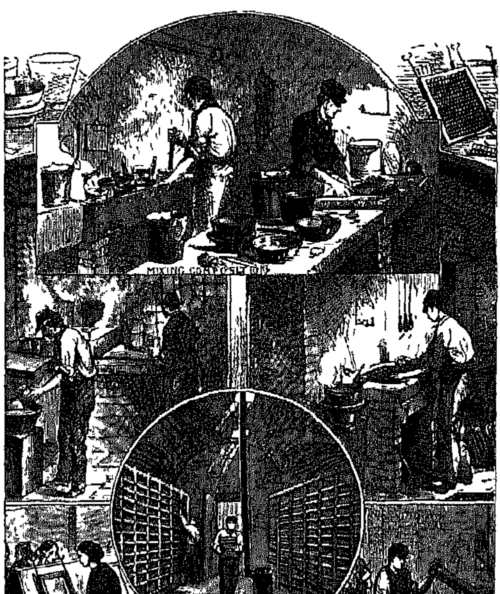
'There let Hymen oft appear
In saffron robe, with taper clear.'

The novice nun still holds a lighted taper as part of the ceremonial of her dedication as a 'bride of Christ'.

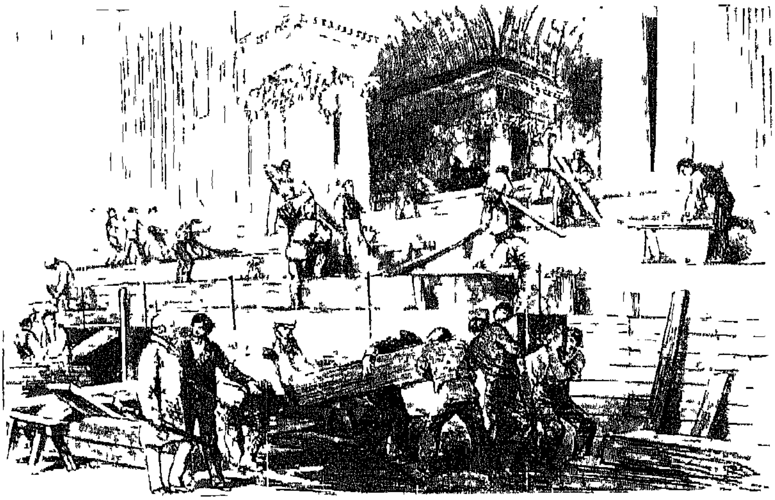
A custom less strange to modern ideas was recounted by St. John Chrysostam in the 4th century A.D. Pious parents would not presume to name a newly-born child but would leave the choice to God. A number of lamps would be lit, each bearing a name, and the last to burn out bore the name that should be given to the child. Later practices which are still carried on in the Roman Catholic Church are the blessing and lighting by the Pope of great paschal candles at Eastertide from the wax of which Agnus Dei medals, impressed with a figure of the Lamb of God, are sold or distributed to the faithful to be carried as a protection against evils of all kinds. On December 13th, the Feast of St. Lucy, the days reckoned by the old-style calendar begin to lengthen again. This is symbolized by a ceremony of lighting candles in some countries. In parts of Sweden, where Christianity is only about 1,000 years old, this ceremony is a carry-over from pagan times. Similarly the practice of placing candles round a bier in Christian times comes from one of the oldest superstitions in the world; the provision of lamps in the grave to light the dead through their darkness. The bier of the Emperor Constantine in the 4th century was surrounded by golden candlesticks. Froissart, the chronicler, recorded in the 14th century that before the funeral of the Comte de Foix 24 varlets by day and another 24 by night held great candles



Candling Wine, London, 1821 by I. R. and G. Cruickshank



An English Match Factory, 1870
From Cassell's *Technical Educator*



Work by gas light in St Paul's Cathedral, 1852
Illustrated London News

Agricultural work by arc lamp, 1881

round the bier. These candles were probably similar to those required by Sir John Atkins of Chichester whose will, dated 1488, specified that 'on the days of my burial and trental each of six poor men is to have a gown of white fryse down to the feet with a hood, and to hold in his hand on each day a 4 lb. candle'. A 13th-century fresco in the Monastery of Sopocani in Yugoslavia shows dozens of mourners bearing candles at the top of torch staves as they surge round the bier of the Virgin.

The 'perpetual lamp' for use by the dead has been the subject of rumour and legend. When, after 1,500 years, the tomb of Cicero's daughter Tullia was opened, it was said that the lamp there was still burning. This, if there was either a supply of natural gas and some seepage of air, or even a natural oil supply and an asbestos wick, is not wholly impossible. An asbestos wick tried experimentally, worked well without apparent deterioration but the difference between a couple of days and a couple of centuries of use is impossible to estimate. Another theory is that the tomb openers carried lights which ignited a gas pocket in the tomb and, by setting fire to debris in the lamp, gave the impression of perpetuity. The whole story is probably just a medieval tale. Cowper refers to it in:

> 'Our wasted oil unprofitably burns
> Like hidden lamps in old sepulchral urns.'

And there are long accounts of alleged instances in *De Lucernis* by F. Licetus.

Even now there are widespread practices in which lights of one kind or another are associated with death. There are, for example, the candles round the bier; the burning of candles for the dead on All Souls' day; the Japanese feast of lanterns; and similar uses of light by the Chinese and by some of the American aborigines. Some of these developed, no doubt, from the desire to give to the dead facilities that they may have enjoyed in life; but others to preserve the corpse from reanimation by evil supernatural beings; or to prevent the late tenant, who might be revengeful, from returning to harm the survivors; or in other cases to show the spirits of the dead that they were still remembered.

Cotgrave's Dictionary of 1611 gives an interesting definition of the French term '*A la Chandelle*'—'By candle light; in extremitie, or at the point of death, when a man is ready to give up the ghost (for then the Romanists light candles upon a conceit that evil spirits are driven away thereby)'.

The link between ancient superstition and modern beliefs is often fairly clear. One of the oldest pagan superstitions was that the dead returned to their old haunts at set times, and lights were set out to guide them. These beliefs were so ingrained in man that acceptance of a new religion could not eliminate the atavistic fear of displeasing the departed spirits by allowing them to return unheralded. On All Souls' Day in Christian churches it became customary to burn a votive candle for the souls of the dead, thus effecting a neat compromise. In some parts of South-East Europe, where the older tradition is still strong, it was and may still be customary to leave the destination of these votive lights to God. On November 1st, egg-shells were filled with oil, provided with wicks, and floated down rivers to give light and comfort to the departed. The Hindus had a similar custom, but in their case they pursued their egg-shell lights as they floated down the Ganges. A light burning long and clear meant a long life, but one quickly extinguished was a portent of doom. It has been common in most of Europe for people to become uneasy and to foretell an impending disaster if a lamp or candle should suddenly and unaccountably be extinguished. At the auctioning of church acres by the candle in Britain this superstition was particularly strong.

There is an extensive folk-lore of lighting which cannot be gone into in detail although some of it would be an attractive study. In the 18th century, for instance, the behaviour of crude spout wick lamps was associated with future events. A green flame, to the japanners of Wolverhampton in the English Midlands, meant a witch was near; a spark from a trimmed wick meant a funeral, and a blue flame was supposed to foretell a change in the wind. A 'cauliflower' in the wick was said by the Romans to indicate rain. Apuleius in *The Golden Ass* tells how Pamphile studied the lamp wick and announced that it would rain heavily the next day. The custom of drawing the curtains of a house where a death has occurred is obviously connected with the very ancient association of death and darkness. Even the parable of the wise and foolish virgins may contain contemporary allusions, the force of which now escapes us.

Some customs were simply the outcome of literal interpretations of words. One result in the 17th century Revised Version of the Bible of the substitution of the word 'lantern' for 'lamp' in 'Thy word is a lamp to my feet' was that a religious extremist, Sir Humphrey Edwin, used his position as Lord Mayor of London in 1697–8 to persuade, cajole and threaten the citizens into providing for public and private use lanterns of which the windows were pages from the

old Geneva bibles. He regarded such lanterns, as objects of piety and all others as heretical. His career, marked by other extravagances, was short and stormy, but the same kind of literal interpretation of the original biblical phrase had already resulted, according to St. Jerome, in the 4th century A.D., in the practice by Eastern churches of lighting a candle in full daylight for the reading of the Angelus as a symbol of the Divine Light. A tall candle was also held aloft each night for Louis XIV as he said his prayers, and to be allotted the task of holding it was deemed a great privilege. In the bedroom used by Louis at Vaux-le-Vicomte there were also 8 candles in wall sconces, 2 dozen more in standing candelabra and 30 or so in two crystal chandeliers. The candle for prayer, in the circumstances, seems clearly symbolic.

We read the bible in translation (the same applies to other works) and the meanings given by the words chosen by the translator may not always convey the original meaning to the reader. Thus the 'seven branched candlestick' of Exodus was a device for supporting seven oil lamps. The ruse by which, with 300 picked men, Gideon routed the host of the Midianites is described in the English Revised Version (Judges, Ch. VII) as the carrying of torches in pitchers which they shattered at the moment of surprise. The French version suggests that these were 'lights', not necessarily torches; and Roger Bacon in *De Mirabili Potestate Artis et Natura* made a topical suggestion, for his time, that what was meant was a sort of grenade, or Gregorian fire; how and why they 'held the torches in their left hands and the trumpets in their right hands to blow withal' (R.V.) is in that case far from clear.

The decoration of lamps may equally be misinterpreted. The markings on many Sumerian Lamps were essentially prophylactic rather than decorative, for powerful spirits had to be appeased. The exceedingly erotic symbols on some Roman lamps were frequently connected with fertility rites and would have seemed neither exceptional nor libidinous to the people of the time. There was a considerable element of mysticism in the Roman view of the lamp. Apart from providing lamps for the dead they were kept burning perpetually before the altars of their household gods and even in the rest of his home a Roman would not wish to extinguish a lamp once lit, but would let it burn out of its own accord. This was partly to serve others who might come that way, but also out of respect for the flame itself. It stands to reason that the stench and smoke of untended lamps in Roman households must have been accepted as an inevitable consequence.

The modern practice, in France, of using a neon glow in place of the flickering sanctuary lamp seems traditionally inadvisable. The effect is even flatter and more uninspiring than the unblinking lights with which the Lascaux cave paintings are illuminated to serve the tourist trade.

The lighting of the places of worship themselves followed to some extent general practice of the times, but with certain modifications attributable to the position of temple or church as a centre of activity and the venue of feast-day celebrations. From the sunshine of ancient Egypt the worshipper passed into a temple packed with columns and lit only by small windows in the roof above a central avenue. The inner sanctuaries were successively decreased in height and increased in darkness until final blackness was reached. Between pillars there were huge statues, simple but dominating. On the walls were brightly coloured paintings, flat or in bas-relief, of which the subjects were sometimes grotesque. The whole was obviously to be viewed by the light of flickering processional torches and the momentary lighting up of figures of men with the heads of birds and other bizarre inventions of the Egyptian pantheon must have made a powerful impression on the beholder. Sometimes the inner sanctuary was so arranged that a shaft of sunlight illuminated the shrine of the God; and the statue of Memnon was said to have sung when the first rays of the sun struck the stone. The same principle of mysterious darkness was carried on into the Christian era, the Roman-arched cathedral at Elne in the south of France, being an excellent 10th-century example.

The holy places or sanctuaries became the centres of illumination, but it is improbable that the whole of the 1,370 sanctuary lamps before the altar in 8th-century St. Peter's in Rome were kept alight at times other than feast days and special occasions. In most churches the votive candles offered by the faithful helped to spin out the dark hours in which a single sanctuary lamp might be the sole general lighting.

For special occasions the sums spent on lighting were often thought worthy of record. Thus, in 1432, the lighting of the church of Notre Dame de Senlis on Easter Day was recorded as follows:

13 candles, each of 2 lbs. for the high altar
24 pounds for the children's candelabra
16 lbs, for two flambeaux
16 lbs. for the pascal candle
40 candles, each of ¼lb. for the corners and sides.

The whole consuming, apart from the High Altar, 66 lbs. of wax.

This pales into insignificance beside the 700 fat candles burning to illuminate the scene portrayed by Elias Martin in Sweden during the christening of the Duke of Södermanland at the end of the 18th

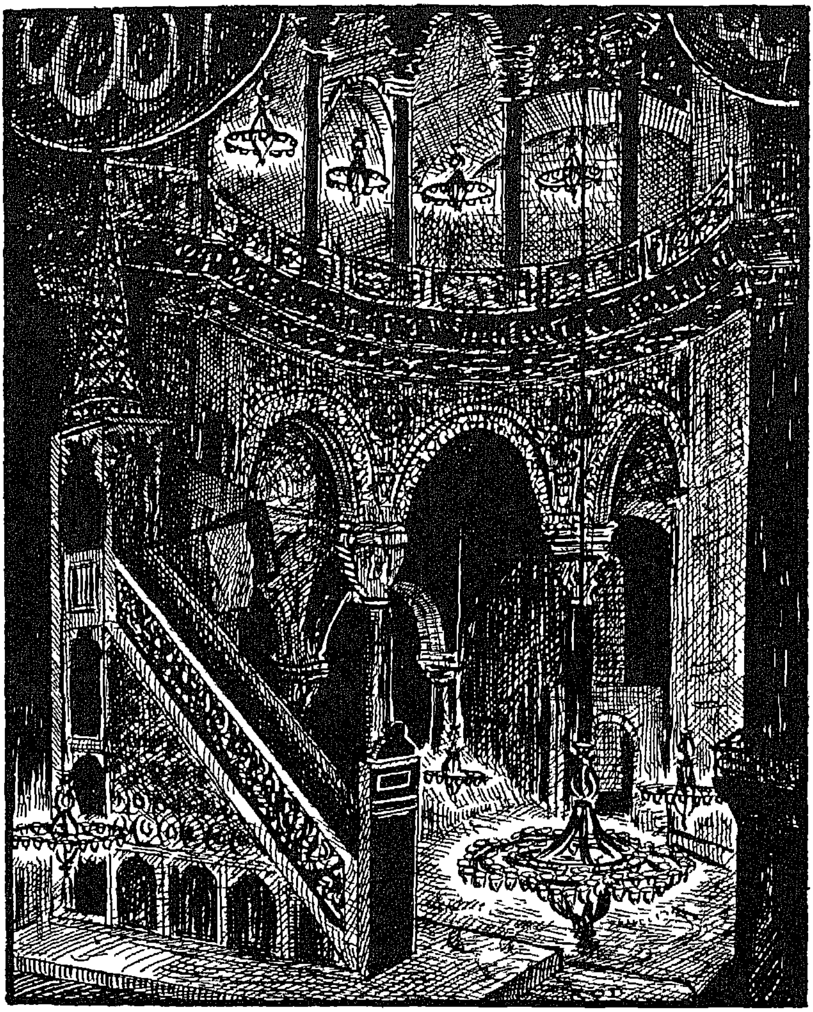


Fig. 41. Lighting of Santa Sophia by low slung clusters of glass float-wicks.

century, and even that cannot match the prodigal scene within Notre Dame Cathedral, Paris, for the funeral of King Philippe in 1746: 1,600 tall candles were alight within the elaborate erection containing the catafalque. In 1851, for the funeral of the Duke of Wellington,

St. Paul's Cathedral in London was blacked out and illuminated by innumerable gas jets. (Plates 2, 29, 30.)

The glass lamp with a float wick was known in 4th-century Byzantium and developed into the characteristic mosque lamp. In St. Sophia in Istanbul (Constantinople) low-hung clusters of hundreds of simple float-wick lamps, set about 9 feet above the floor-level, gave feeble illumination to the precincts from 1847 to very recent times. They were probably more elaborate repetitions of a very much earlier technique. For float-wicks today it is usual to put half an inch of thin wax taper through a hole in a thin metal plate protecting the top of a cork float from the flame. The advantage of the wax taper is that it is easy to ignite compared with a plain fibre wick. The low height of the lamps at St. Sophia was nothing unusual. Crystal chandeliers, so common in the salons of the wealthy, were usually dropped quite a long way from the high ceilings on ropes or chains. The coronas in churches were similarly placed. In some cases they could be wound up and down on drums placed above ceiling-level. The fact is that both candles and float-wick oil lamps gave an area of brightness that hardly pierced the distant gloom in a structure so vast as a high-vaulted church.

This was entirely in keeping with the ancient idea of plunging the worshippers firstly into a frightening and mysterious darkness and then, at the moment of mystical experience, relieving their fears by the use of light. The modern use of brilliant, pervading light may psychologically be a mistake. It is, at all events, contrary to the age-old technique by which man has conditioned himself to the mysteries of religious experience.

A few years earlier than the St. Sophia clusters, Gautier in his *Journey in Spain* of 1840 described the illumination of the church at Vittoria as:

> '*Quelques petites lampes tremblotaient sinistrement jaunes et enfumées comme des étoiles dans du brouillard.*'[1]

This is probably as good a short description as any of the usual type of church lighting, up to the latter half of the 19th century, at times other than those of the main services. Even for those few services taken outside the hours of daylight it is doubtful whether more than the few candles on the altar would be added to this general illumination except on the occasion of special feasts or ceremonies.

The first attempts to provide a blaze of light in churches—for

[1] 'Some tiny lamps, yellow and smoking, flickering balefully like stars in a mist.'

special occasions—were by the prodigal use of candles. Later gas jets were used, and also Argand gas burners of multi-ringed design. As much as 1,200 candles was claimed as the lighting power of a single Argand burner of the largest size, but units of 300 and 150 candle-power were more common. Both heat and gas consumption were considerable.

Electric light was not wholly successful for a long time and at the turn of the 20th century, for instance, the cathedrals at Digne and Uzés in France blazed under the light of some 150 acetylene burners. Earlier still, in 1897, 200 acetylene burners were in use at the Grande Trappe de Soligny in Mayenne, but only a proportion of these were in the chapel. The City Temple, in London, had been lit by Edison carbon filament electric lamps as early as 1882, but for the vastness of the average church the earlier filament lamps were economically unsound while arc lamps were much too crudely material in the atmosphere their light created. Filament lamps for lighting began to come into their own shortly after the introduction of the drawn tungsten filament in 1909. Within two or three years there were many installations.

The arc lamp was unthinkable for church use, and yet, in later times, there have been examples of church lighting almost as crude. Altars and sanctuaries have been subjected to projector-lamp treatment of a kind that would seem to have been borrowed from the music-hall, while magnificent stained glass has been left to present a flat, black face to the congregation. Chancel and nave have been lit highly, flatly and uniformly; sometimes from fluorescent sources. Church buildings themselves, even new ones, have conformed to historical precedent and yet in lighting them historical precedents have been rejected. The exteriors can profitably gain from flood-lighting, in many cases. Flood-lighting from without can make stained glass, from within, resume the function that it was designed to fulfil by daylight. But a high-intensity flat light within can destroy the effect of height, of labyrinthine mystery and of that awe that has been one of the major aims of the church builder since at least the days of Memnon.

Every church presents its own problems. These observations mean that they are most likely to be solved by the lighting engineer, possibly in consultation with the architect. Today the lighting engineer is a specialist. The vicar with his churchwardens and the local electrician are together unlikely to do as well, and may evolve something not only unsatisfactory but more expensive to maintain and service.

Even the lighting engineer must be instructed that his task is so to dispose modern lighting facilities that they can be accepted unquestionably by a congregation conditioned by a tradition extending over thousands of years. For a coronation that is to be televised an uncompromising blaze of light may be acceptable. Where man is to wrestle with his individual soul the blaze may bring him nearer to the policeman than to God.

CHAPTER VII

Light for the Theatre

It is only in the past hundred years that the use of light to aid production in the theatre has advanced notably beyond what was available to the ancient Greeks. Greek drama was performed by daylight or moonlight, and to some extent torches could be employed at night to give effects. Scenery, other than natural, was first introduced in 465 B.C. and there was even an 'effects' scene made by painting lightning flashes on the three sides of a rapidly revolving prism-shaped structure. In Rome at the time of Tiberius it was said that 500 slaves bearing torches conducted the audience home after a show, but there is no reason to believe that the show itself took place except in daylight. The Greek and Roman theatres were open to the air, and anyone who has enjoyed a performance out-of-doors in the soft Mediterranean spring or summer nights will hardly require convincing that the need for enclosed theatres cannot have been felt very much. In a climate such as that of Britain the open-air theatre was a much less desirable proposition; and yet, up to late medieval times at least, there was no real alternative. The mummers who travelled from castle to castle in Europe were vagabonds whose entertainments were of the crudest kind; a little juggling, a little music and a broad sketch that appealed to unlettered minds by leaving little to the imagination was good enough for shelter and board, and possibly provender or a coin or two to help on the way to the next performance. These performances were given in the courtyards, or exceptionally if the weather demanded it, in the halls inside the castles. There was no special lighting apart possibly from a more than customary number of torches or candles. The courtyard of the ducal castle in which was to be played the farce of Altisidora's revival before Don Quixote was described by Cervantes as lit by about a hundred torches set in their sconces with more than five hundred lamps set around the galleries of the court. Altisidora's bier, about six feet off the ground, reposed on top

of steps on which a hundred wax tapers were burning. To Don Quixote and Sancho Panza the scene, though the night was rather dark, seemed bright as day.

In various parts of England a different class of entertainment, still robust in humour but with a religious significance, arose in the 'Mystery Plays' that were performed in various localities on festival days. Each locality had its own traditional plays, the repertoire being split up between the various craft guilds. At the beginning the plays were performed in or near the churches, but about the 13th century the players began to tour the city with a double-tiered travelling platform. They would stop outside the houses of those who, by their benefactions, had earned the honour. As many as a dozen or more performances might be given in a day, starting at four or five in the morning and finishing long after dark. The play was acted on the top platform, where it could best be seen by the worthy subscribing citizens at their upper-floor windows. The actors changed in the curtained space underneath. York, Chester, Coventry, Wakefield and places in Cornwall were among the very many towns and even villages where such performances were presented.

These mystery plays originated at least 1,000 years ago and continued for quite 500 years. When daylight was inadequate the torchbearers appeared, but where they stood to illuminate the performance is not clear. In *Romeo and Juliet* Shakespeare refers to the use of torchbearers in a similar way. In Act i, Scene 4, Romeo, Mercutio, Benvolia and '5 or 6 Maskers, torch-bearers, etc.' enter the street where a performance is to be given:

> 'Give me torch,' says Romeo, 'I am not for this ambling.
> Being but heavy, I will bear the light.'

Later in the same scene he confirms his reluctance to take part:

> 'A torch for me . . .
> I'll be a candle holder and look on.'

Permanent theatres in Britain, such as the old Globe Theatre in London, at which so many of Shakespeare's plays were produced, were largely open to the sky and plays took place only in daylight. According to Dyce, who was an authority on Shakespeare in the mid-19th century, the stage was lit by 'two ample branches, of a form similar to those now hung in churches', but in the only known contemporary drawing of an Elizabethan playhouse (of the Swan,

drawn by Johannes de Witt about 1696) there is no evidence of any lighting at all either on the stage or off it, other than daylight. Dyce may have been referring to private playhouses, of which the first, opened at Blackfriars in 1577, was roofed over.

Cotgrave's French-English Dictionary of 1611 defined a '*Fallot*' as 'A cresset light (such as they use in playhouses) made of ropes wreathed, pitched and put into small and open cages of iron.' Before that, in 1566, there is a record in Latin of a performance before the Queen in Christ Church College Hall, Oxford, which was translated by Professor Schelling as follows:

'Cressets, lamps and burning candles made a brilliant light there. With so many lights arranged in branches and circles, and with so many torches here and there, giving forth a flickering gleam of varying power, the place was resplendent, so that the lights seemed to shine like the day and to aid the splendour of the plays by their great brightness.'

Cressets and torches had obvious disadvantages and before long they seem to have given way to candles and oil lamps. In Diderot's encyclopaedia, a century and a half later than Cotgrave, the '*Fallot*' is no longer associated with playhouses, but is illustrated as a folding iron cage covered in silk and holding two candles. These theatre lights generated smoke and heat which, in roofed theatres, had to escape into the atmosphere. It was therefore necessary to provide a 'lantern' in the roof as a ventilator. Through the slatted sides of the lantern there rose into the outside air an effluvium compounded of heat, smoke, sweat and the pungency of unwashed bodies against which the more sensitive members of the audience protected themselves to some extent by smelling periodically at a hole pierced in an orange. Charles II's meeting with Nell Gwynne, the orange seller, becomes less difficult to understand.

The question of ventilation was very serious. Sir Frederick French, writing to *The Mechanic & Chemist* in June, 1839, observed that 'it is said that one wax candle consumes as much oxygen as two men, and 240 candles will deteriorate the atmosphere as much as the respiration of 700 men'. There is, in the Louvre, a large painting by Pannini of a theatre scene entitled '*Concert donné a l'occasion de la naissance du dauphin, fils de Louis XV*'. This was in 1729. Allowing for what cannot be seen in the picture there must have been at least 700 candles burning in the theatre. No wonder that Lavoisier, the famous chemist, estimated that the quantity of oxygen, or vital air

in a theatre diminished by nearly one-fourth from the commencement to the end of a play.

The stage itself seems sometimes to have been lit, rather flatly and inadequately, by candles or oil lamps from at least the 15th century. The nearest approximations to effects were 'squibs' and other fireworks let off as a background for devils—who figured very prominently in early plays—and, in the middle of the 16th century, the placing of bottles filled with red and blue liquids in front of the candles for certain scenes. This device was described by Sebastiano Serlio, the

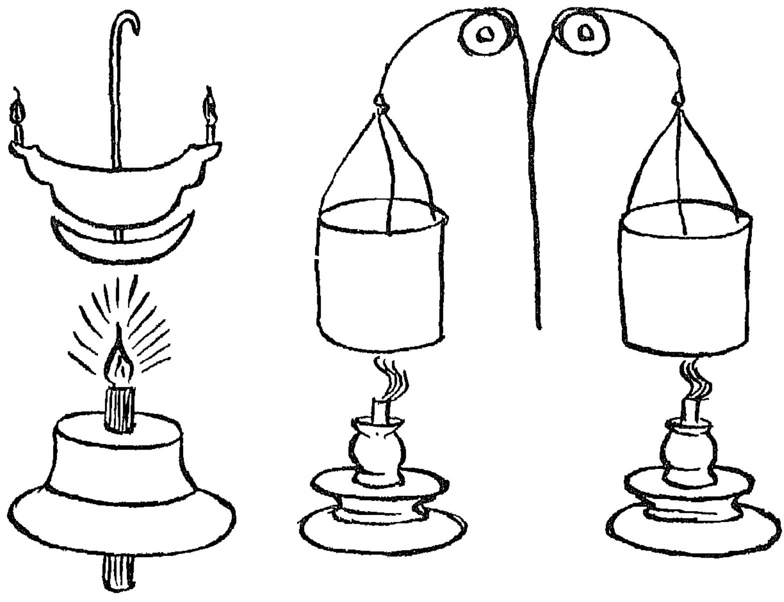


Fig. 42. From *Scenes and Machines*, by Nicola Sabbatine, 1638.

first edition of whose work on architecture was published in 1545. He also told how lightning could be simulated by firing a charge of 'vernis or sulphine' powder at a candle burning in a high place. In the year 1533, Rabelais in *Pantagruel*, Book IV, Ch. 13, relates how a gang of actors, led by François Villon, paraded through a town with long lighted firebrands on which they threw great handfuls of powdered resin at every street corner to produce terrible flames and smoke. This delighted the crowd but frightened small children. In the 17th century Master Peter's puppet show, described by Cervantes, was lit all round by a multitude of wax tapers so that it looked gay and resplendent.

Nicola Sabbatine published, in 1638, a book[1] on *Scenes andMachines* in which he had advice to give on the subject of stage lighting. He referred to float-lights and warned that in his experience they were not very good. The lights had to be placed not too high, so that they could be seen above the parapet, nor too low. They caused smoke, especially if the wicks were too long; and this made the stage misty and affected the speech and pronunciation of the actors who looked pale, as though suffering from a fever. Presumably these floats were float-wick lamps used as footlights and it is interesting to recall that even today the footlights are commonly referred to as 'floats'.

Sabbatine also suggested the suspension of 2-wick oil lamps to light the sky on the stage. From his crude drawing it looks as though a pan to catch the oil drops was suspended underneath. For infernal scenes torches were poked through holes in the stage which from the illustration given had protection from fire by the use of metal or ceramic guards. Another illustration was of a most interesting device for dimming the scene by lowering cylinders, presumably of metal, down over the flames of oil lamps by means of cords and pulleys. The spectators themselves required light, and 3 candles on a standing candelabrum was the means illustrated by Sabbatine. The economy exercised was frequently excessive and the spectators were expected to assemble in almost unrelieved gloom. In 1609 Henry IV of France actually issued an edict compelling under pain of severe penalties the placing of lanterns in the pit, balconies and corridors of theatres.

Illustrations of footlights date at least to 1673. A publication of that date, *The Wits, or Sport upon Sport* by Francis Kirkman, has a single illustration showing the stage of the Red Bull playhouse in Clerkenwell, London. Two candelabra with 8 candles in each, hang above the stage for general lighting. At the front are 6 double-wick oil lamps. There was no scenery although scenery was first introduced to the English stage at Dukes' Theatre, Lincoln's Inn, London, in 1661.

In France, as in Britain, the auditorium lights were undiminished when the play began until Servandou, at the palace of the Tuileries, drew the auditorium chandeliers up towards the ceiling when the curtain rose. A similar technique was used in reverse at the second Drury Lane Theatre built by Wren in 1674. The stage was lit by two hanging coronas of 30 candles each and both these and probably

[1] *Practica di Fabricar Scene e Machine*, by N. Sabbatine. Ravenna, 1638.

Fig. 43. The Stage of the Red Bull playhouse, London, *from Francis Kirkman's The Wits, or Sport upon Sport,* 1673.

the auditorium chandelier as well were lowered to dazzle the audience so that scene-changing could proceed almost unnoticed behind the lights.

Sometimes theatre lighting was lavish. At Versailles in 1668 there were 32 crystal chandeliers containing well over 300 bougies, but this was hardly normal. Perrault, writing in 1682, on '*Parallèle des*

anciens et des modernes en ce qui regard la poesie' gives what is probably a more usual description:

'*Tout la lumière consistait d'abord en quelques chandelles dans des plaques de fer-blanc attachées au tapisseries; mais comme elles n'éclairent les acteurs que par derrière et un peu par les côtes, ce qui les rendait presque tous noirs, on s'avisa de faire des chandeliers avec deux lattes mises en croix, portant chacun quatre chandelles, pour mettre au devant du théâtre. Les chandeliers, suspendus grossièrement avec des cordes et des pouliés apparentes, se houssaient et se baissaient sans artifice at par main d'homme pour les allumer et les moucher.*'[1]

The snuffing of the lights, if they were of tallow, was most important and it was by no means unusual for an actor, in the middle of his

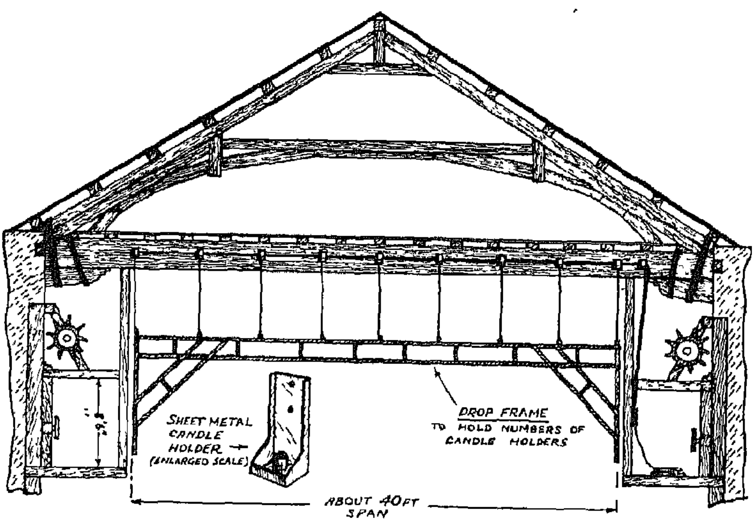


Fig. 44. Drop frame for lighting tops of scenery, *c.* 1740. *Diderot.*

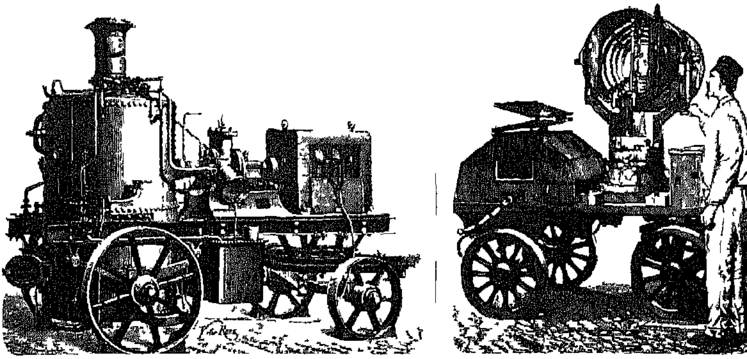
part, to attend to a smoking candle. Even wax candles were better with attention. There was a special attendant for candle snuffing as a

[1] 'Lighting at first consisted of a few candles in tinned iron holders attached to the drapes; but the actors appeared almost black because they were only illuminated from the rear and to a small extent from the sides. Chandeliers were then made in the form of a cross bearing four candles and hung in front of the stage. Chandeliers suspended by primitive rope and pulley apparatus could be raised or lowered easily by hand for lighting or snuffing.'

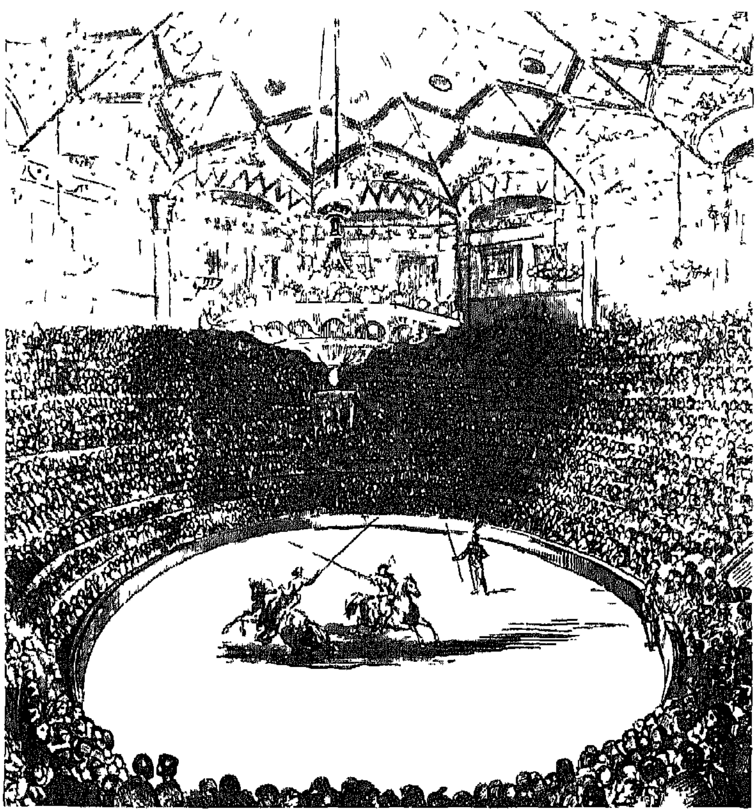
rule and even though he might interrupt the play nothing was thought of it. Some of the professional snuffers became so expert that in the 18th century they were frequently applauded.

Diderot, in a supplement to his famous encyclopædia in 1772, deals with the theatre and its mechanisms in great detail, but has surprisingly little to say about lighting. He does mention the great number of lights that are customarily used to light the acting area and also describes the light stores, called '*les petites caves*', opening off the stage, 'with many rows of staging for conveniently placing, preparing and lighting the lamps, extending up to the full height'. In the light room, with its tall doorway, there are 'heated cauldrons to liquefy the oil if it should congeal, and many outlets to a tall chimney to take away the smoke'. This is from a description of the theatre at Turin, opened late in the year 1740, and seems to imply oil or grease lamps rather than candles for stage lighting. It is known that thirty years later, at Fountainebleau, oil lamps with reflectors behind the wicks, were used. Diderot also describes at the Turin theatre a mechanism for lighting the tops of the drop scenes by means of a cradle that can be pulled up and down to the required levels by ropes and to which a number of simple sheet metal candle holders are attached.

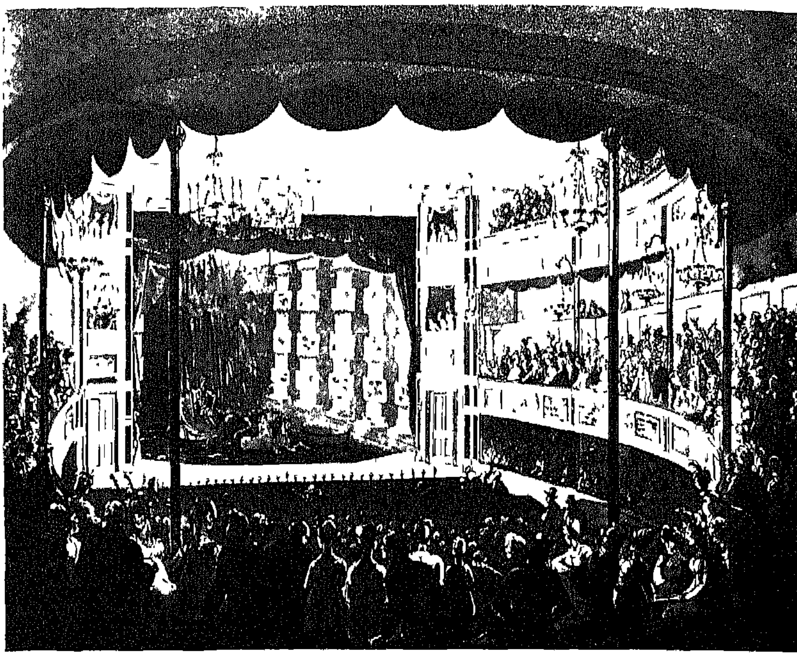
At this same theatre in Turin, before and after the opera, a grand candelabrum carrying a dozen torches (presumably flambeaux or bougies which would burn as brightly as perhaps half a dozen ordinary candles) was lowered at stage-front level for general illumination. Normally these grand candelabra were in the centre of the auditorium although, in a print showing the *Comédie-Française* in 1726, two candelabra at the level of the front of the stage are shown lowered practically to the boards to illuminate a notice on the curtain advertising a series of prints for sale depicting famous scenes from the comedies of Molière (Plate 23*a*). It was claimed for the candelabrum at Turin that the position improved the acoustics of the theatre as the ceiling was an uninterrupted solid, and it also did less damage to the decorations which soon became dirty from the smoke of a central fixture. The central candelabrum was said to be uncomfortable for the spectators in the tiers who were dazzled by the great brilliance of the light, and on the floor upon whom there fell dust and other filth from the opening above. These candelabra were wound up and down by hand from positions up under the roof from which access to the lights was also possible. They could be counterweighted after the same manner as the drop scenes, the winding ropes commonly



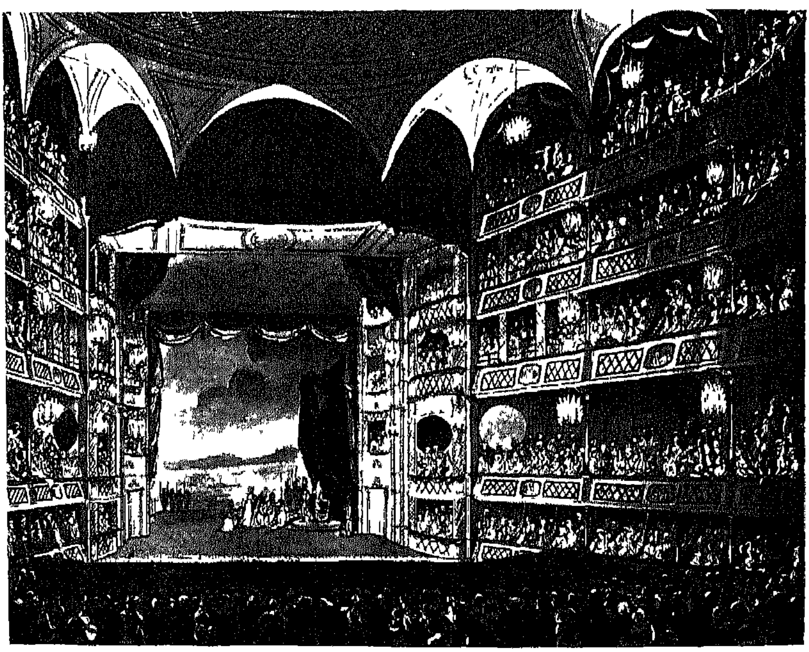
Mangin's Searchlight projector and generating plant, 1877-81



Gas light at the Winter Circus, Paris, 1852
Illustrated London News



Sadler's Wells Theatre, 1809 by Pugin and Rowlandson



Drury Lane Theatre by Pugin and Rowlandson

passing over an arrangement of unequal diameter drums so that the counterweights need only travel a relatively short distance.

The coronas or candelabra suspended over the acting area were usually in full view of the audience and at Drury Lane (Plate 22), for instance, were not concealed behind sky borders until the time of Sheridan's management in 1784.[1] In a print of Sadler's Wells Theatre, London, in 1809 the auditorium would appear to be quite well lit by numerous chandeliers although the action on the stage is proceeding (Plate 22). Here the sky borders obviously conceal the stage lighting with the exception of a row of 32 footlights. These look as though they might be robustly burning thick tow wicks in lamps shaped like torches.

Candelabra did not necessarily contain candles. At Astley's Circus in London at the end of the 18th century the arena was lit by 28 or 30 candelabra each containing a number of lamps with shades of various colours. In all there were 1,200 wicks burning. The *Comédie-Française,* in 1781, was lit according to a suggestion by M. Lavoisier. Over the acting area were oil lamps in elliptical reflectors that also acted as chimneys. It was claimed that this eliminated an old fault '*d'en présenter les objets d'une manière contraire a la nature en les éclairant de bas en haut, lorsque'ils devraient, dans l'ordre physique, l'etre de haut en bas*'. Today in addition to lighting from the sides and below, it is usual to employ high-intensity top lighting, which entirely agrees with the theories of M. Lavoisier.

It was in 1784 that Argand burners were introduced to London and very soon afterwards they were adapted to the theatre. By the use of coloured glass chimneys they could be used to give a limited range of colour effects, and at the first Haymarket Theatre a system of levers was used to drop coloured glasses over the lamps for moonlight effects.[2] Such lamps with reverberators or reflectors were placed at the ends of boxes on both sides to light the proscenium instead of the usual footlights at a greenhouse turned into a theatre at Blenheim for family theatricals between 1787 and 1789. The Argand oil lamp had hardly got into its stride, however, before gas lighting burst on to the scene with what might justly be called theatrical brilliance.

Gas lighting, in the commercial sense, was born in the theatre. Some kind of inflammable gas was used by a German chemist, Diller,

[1] *The Evolution of Stage Lighting,* by L. G. Applebee, F.I.E.S., Journal of the Royal Society of Arts, London, Vol. XCIV, No. 4723, August 1946.

[2] *The Elizabethen Playhouse and Other Studies,* by W. J. Lawrence. Shakespeare Head Press, 1913.

in a display of 'Philosophical Fireworks' at the English Opera House (later called the Lyceum) in 1788. Sixteen years later another German, F. A. Winser, took over the same theatre from Madame Tussaud for a series of demonstrations of lighting from coal gas generated in a retort on the stage. This was a truly theatrical performance, for Winser had little English and simply conducted the experiments while an assistant read a lecture from the orchestra pit. Boys circulated among the audience distributing handbills calling for investments in the new 'Gas, Light and Heat Co.' He was calling for support to the extent of 20,000 shares of £50, £5 paid up—but holders of 100 shares could have them for £100, later reduced to £50. Profits were estimated at £570 per annum per share after the first year. Incredibly enough he got his money to the extent of £50,000, and never paid a dividend; but out of it he formed the company that later became the huge Gas, Light & Coke Co. of London. He was responsible for the first demonstration of gas street-lighting along the walls of his house in the Mall, London, in 1805. In 1809 Pall Mall was lit by gas—the first public street-lighting of the kind.

Gas, in those days, was simply burned at holes pierced in iron tubes. The holes rusted up, the iron over-cooled the flame, and the gas was of unreliable quality. Nevertheless the simplicity of the method soon led to an impressive demonstration. A pagoda, 80 feet high, built in St. James's Park, as part of the premature peace celebrations of 1814, was outlined with pierced iron tubes fed by a gas supply. At an appropriate moment pilot gas jets at the base of the tower were lit and the flames travelled up outside the lengths of the tubes as the gas emerged horizontally from successive holes. At rehearsal 10,000 jets were lit in this way in a few seconds, to provide a most astonishing effect. It was a pity, in fact, that on the following night Sir William Congreve insisted that a display of his fireworks should precede rather than follow this *pièce de résistance*. A misdirected rocket burnt the pagoda down, the visiting monarchs having to be satisfied with the sight of the top two stories falling into the lake. However, a system was born that, translated into the theatre, persisted until the end of the century. Three years later, in 1817, both the stage and auditorium at the Lyceum were gas-lit.

Refinements, for which Sir Henry Irving was said to be responsible at the Lyceum and Sir Augustus Harris at Drury Lane, were in the employment of variations in pressure to control intensity through gas valves and in blending colours obtained by revolving colour screens in front of the flames. The 'gas plate', as the regulator was called,

became the forerunner of the modern dimmer regulator. One great disadvantage of gas was the high temperature to which a great number of lights could and did raise the acting area. Sir Henry Irving always insisted that the house lights should be darkened while the stage show was on. This unusual insistence, which started about 1856, soon became commonplace, but before gas lighting was available it was not so easy of accomplishment (Plate 23*b*).

Drummond invented limelight in 1796. He found that a piece of lime glowed brilliantly if heated by an oxy-hydrogen flame, and in 1839 a similar light was used for flood-lighting Vauxhall Gardens and other places in London, but it was more than half a century before Drummond's invention seems to have reached the theatre. There is some inferential evidence that in 1856 at the Princesses Theatre, London, this technique was used with a lens in front of the lime to give a spotlight. About 1860 the technique was quite well known. The operator sat on bags containing the oxygen and hydrogen when he wished to increase the pressure. The results of a disastrous accident at Drury Lane, where one of the bags burst and created an explosive atmosphere near the high-temperature flame, led to the introduction of regulations making iron cylinders compulsory. Limelight needs only this brief reference from the lighting point of view. In a history of stage production during the next three-quarters of a century it might well overshadow most other references, so important has been its influence.

Meanwhile electric lighting, which has now driven the limelight into obscurity, seems in its early applications to have been mainly the work of M. Duboscq, an associate of Foucault in Paris. There were no electric generators when the theatre first experienced the electric arc, the source of power being a battery of the wet cells invented by Count Bunsen in Germany. The output from such cells could only be maintained for a very limited period, so at first the arc lamp was used only for special effects. The first of these was M. Duboscq's contrivance for the rising sun in a performance of *The Prophet* at the Grand Opera in Paris. That was in 1846.

The theatre-goers of Paris were delighted and astonished by what was, to us, a very simple contrivance. An arc was struck at the focus of a parabolic mirror in front of which was a silk screen. On this a luminous circle would be seen. The whole apparatus was pulled up towards the catwalks above at a suitable rate, the mechanism, other than the luminous disc which shone through, being concealed by a fine net curtain or 'gauze' between the audience and the disc.

It was not until 1853 that M. Duboscq introduced his next notable effect, a luminous fountain made by projecting on to a net screen the image of fine jets of water playing in a glass cylinder, behind which he mounted his arc lamps and optical system. For the opera *Faust* he improved his effect by introducing coloured glasses between the arc and the glass cylinder. In 1855 he was given a permanent appointment as deviser of effects at the Opera. There followed, usually at considerable intervals, a number of novelties of which the most striking were the rainbow and the 'magic mirror'.

The rainbow was devised in 1860 for the opera *Moses*. Previously

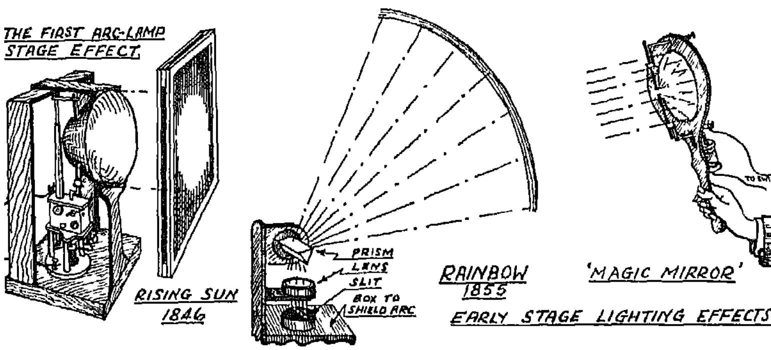


Fig. 45. Early stage lighting effects.

it had been shown, very indifferently, by lamps behind semi-transparent coloured paper arcs. Now M. Duboscq mounted a slit, lens and prism in front of a light-tight box containing an arc fed by 100 Bunsen cells. He projected a brilliant rainbow on to a net curtain 5 metres in front of the apparatus.

The 'magic mirror', later adapted to the variety stage, was just a concave mirror with an arc at its focus. The lower carbon was in a holder that could be jigged up and down by an electro-magnet energised by a commutator. A series of brilliant, quick flashes made a very good imitation of lightning while thunder claps from thin sheets of metal were being generated off-stage. The same arrangement or arc and concave mirror, but without the interrupter, was a little later used to light up large areas of scenery for special effects and, about the same time, an arc with a lens in front and a very simple diaphragm arrangement to control the intensity was used as a spotlight. The lime spot and the electric spot originated, in fact, practically at the same time.

Electric general lighting, which so much put up the ambient level of stage illumination without the unmanageability, smoke and heat of oil, or the lesser unmanageability but unquestionable heat of gas, had to wait for two major developments. The first was the provision or practical electric generation plant. This, to some extent, was overcome in the Holmes generator (see 'Lighthouses'), but electric-arc lighthouses developed very slowly. Meanwhile electro-magnetic machines, such as those of Gramme and Siemens, had improved out of all recognition the efficiency of generation, particularly after the practical invention of the principle of self-excitation in 1866–7. Arc lamps remained the only practical way of utilizing the electric light and, in 1879, the Bellacour Theatre in Lyons was lit throughout by Jablochkoff candles. In the following year the Hippodrome at Paris, not exactly a theatre, but nevertheless a spectacle, was spectacularly lit (Plate 24*a*). The floor area of 65,000 square feet, around which could sit 8,000 spectators, was lit by 20 arc lamps for the track and 120 Jablochkoff candle lamps for the centre and surrounds of the arena. Two 100 horse-power steam-engines drove 25 electric generators for the supply. The installation cost 200,000 francs, but running costs were only 320 francs a night compared with 1200–1500 francs for the previous and much less satisfactory gas installation.

The second development for which the theatre was waiting was what became known as 'the division of the electric light'. Arcs were too concentrated, too varying, too cold in colour, and too uncertain in management. The incandescent electric lamp was awaited. Practical forms were produced by Swan & Edison in 1878–9 and very much improved within the next few years. In 1881 the Paris Opera and the Savoy Theatre, London, shared the distinction of being the first theatres to adopt the new method of illumination; at the Savoy there were a number of machines in the basement totalling over 100 horse-power and apart from a large arc lamp in the street outside there were nearly 1,200 filament lamps in the auditorium, foyers and the stage. The stage had 715 clear lamps, and over 100 tinted blue for night scenes. They were mounted on movable fireproof battens and their brilliance could be controlled by resistances in the generator circuit. The stage manager, in those days, was apparently not so busy that it was thought necessary to allot the task of manipulation elsewhere. Neither was electric light thought reliable enough to dispense with a complete gas plant, which was also installed as a stand-by. Five years later as many as 5,000 lamps were in use at the Opera House in Vienna. About the same time the chorus, in

London, was enlivened by the novel effect of docorating them with electric lights which could be switched on at will.

In 1902 the first attempts were made to produce coloured sky effects by coloured light only, the 'cyclorama' being installed by Mariano Fortuny at the Scala Opera House in Milan. The cyclorama, which is a smooth, light-coloured surface the full height and width of the stage, can also be used for optical projection of scenery and effects, but it must not be in the path of any illumination other than that deliberately cast upon it. The ordinary batten lighting of the stage, with a wide-light-spill, thus became objectionable and of recent years attention has accordingly been concentrated on the lighting of the acting area by numerous funnel-shaped lanterns hanging up among the sky borders and giving a 20° beam of light only. The results have been so good that this type of lighting is now used for all types of productions, whether there are cyclorama effects or not. Footlights are no longer in favour.

Fortuny's cyclorama was a double layer of silk, on a frame, the space in between being exhausted of air to keep the silk wrinkle-free. The frame was curved to sustain the illusion of infinite depth after which purists had sought for so long. In the Opera House at Stuttgart, for instance, there was a proposal around 1770 to rebuild the stage area three times as deep as the auditorium. Even in the days of lavish private patronage or ownership, when a balance between income and expenditure was hardly necessary, an auditorium only one-fifth of the theatre area (allowing for the foyer) seemed a bit extravagant.

The Charlottenburg Opera, in 1912, had a movable plaster cyclorama on the Fortuny principle. In 1916 at Dresden the cyclorama was greatly increased in scale. Projected optical effects, common around 1895, were obviously well suited to the cyclorama. Colour effects were first obtained by Fortuny by reflecting arc lights from coloured silks. Later coloured glass screens were used. The arc required an attendant to regulate the carbons, but although incandescent lamps of 2,000 candle-power had been made as early as 1890 the filaments were not compact enough for control until, in U.S.A. in 1914 (four years later in Britain) the incandescent projector lamp made its appearance. The projector lamp had the inestimable advantage that it could be dimmed from a remote position and therefore there was no limitation in its placing. Previously no arc projector could be placed in any position unless an operator could be placed with it.

With the gas-filled lamp of 1919 and the projector lamp, running temperatures were so hot that no lacquer could stand for long the

surface temperature of the glass bulbs. The result was the introduction of the familiar batten housing for stage lamps in which each lamp is in a compartment fronted by a coloured screen.

For a broad account of the technical details of dimming, reference should be made to the paper by Applebee (loc cit.) which also goes into more details of some of the progress stages. As an example of the extent to which the theatre now makes use of electricity the connected loads of modern theatres provide an illustration. Only a modest proportion of the theoretical maximum load is ever used at one time, as the connected apparatus is there to cover all possible contingencies; but as an indication the total connected load of the Covent Garden Opera House is 850 kilowatts. The Red Army Theatre in Moscow has a 4,145-kilowatt connected load. The control of large amounts of power has now been reduced to a technique of great simplicity so far as the operator is concerned. From a switchboard built (since 1935) like a cinema organ console the operator, in a position giving an admirable view of the stage, operates keys and pedals controlling electrically-operated dimmers and switches in the actual stage-lighting circuits. The wires from the console to the back-stage control position have to carry only a very small electric current as the actual controlling is performed remotely by electronic devices. Fire risk is thus reduced to an almost negligible level. The fluorescent tube has also been pressed into service for general stage lighting in some cases as it may be dimmed as readily as any other lighting medium by devices reducing the voltage across the tube to any level desired. It is not, however, desirable for use with a cyclorama and since about 1930 sharp cut-off flood-light housings covering a severely localized area of stage have become almost universal.

Finally, in the tradition of the effects produced by M. Duboscq, there is the use of black lamps (cutting out visible light, but allowing ultra-violet light to pass through special glass) with fluorescent paints and dyes to produce effects that, like the 'magic mirror', belong more to the variety stage. These fluorescent effects have a certain novelty but are little if any more spectacular than the illuminated chorus girls of sixty or so years before. They could present a formidable problem to the ageing musical comedy actress with an expansive false-tooth smile; for unfortunately most false teeth look black under ultra-violet light.

A question upon which there seems to be an unlimited field for controversy is that of the quality of any particular light source. The scientist carefully analyses the light emanation from any particular

source and may prove conclusively that the non-scientist doesn't know what he or she is talking about. The scientist, if we accept his premises, is right; but the subject is so complex that the right to personal judgment must be conceded in certain cases. Thus, in London, the Lyceum Theatre was the last to adopt electric light (in 1902). This was mainly due to the famous actress Ellen Terry who liked the warm light of gas better than what she regarded as the cold and harsh electric light. That was her opinion. Others did not find electric light cold and harsh and nobody could deny that it was more manageable and spectacular. But others were not actresses of renown who could extract that elusive final fraction more effortlessly under the light they fancied.

THE CINEMA

Lighting for the cinema has provided little matter of general historical interest though, as a specialized study, it may be worth considerable attention. The cinema is new enough for the arc lamp and effective electric generators to have become quite commonplace by the time it was found necessary to move from the open air into the studios. There were, as is inevitable when a demand increases rapidly, many improvements in detail and in ease of manipulation; while optical devices, with which we are not concerned, developed at the same time. A very brief account is given below of changes in lighting principles.

Projectors

Projectors, for throwing the pictures on to the screen, were at first lit by arc lamps which flickered and varied in intensity from too bright to right out, depending on the skill and attention of the operator. Mechanical controls replaced skill to a great extent and the efficiency of the arc made it difficult to replace; but it was the high efficiency, high temperature, low-area filament projector lamp that became the goal of those searching for a quiet, trouble-free light source that generated no fumes. The difficulty, after the tungsten filament was introduced, became the achievement of an economically satisfactory working life and the arc lamp remained supreme for many years. The 'pointalite' lamp, which was in effect an arc between tungsten electrodes in an inert low-pressure atmosphere within a glass bulb, gave some indications of promise in the 1920s, but later the coiled coil, heavy duty tungsten filament came nearer to providing

what was required. About 1936 the high-pressure water-cooled mercury vapour tube was being hailed as a possible solution. Later 'compact source' lamps used a discharge in an atmosphere of mercury, to which cadmium and zinc may have been added, between robust tungsten electrodes. The bulb had to be of quartz to resist the heat generated. Such lamps were in development from about 1946 onwards, but like the water-cooled lamps found arc-lamp competition unbreakable economically.

The arc lamp has remained supreme for all large-scale uses, although smaller projectors may more effectively utilize the tungsten lamp. Research directed towards the use of 'microseconds flash tubes', in which a powerful flash takes place 24 times a second at moments synchronized with those when the jerking film lies stationary, has so far (1957) proved no more than an idea of heart-breaking promise.

Studio Lamps

Batteries of arc lamps, improved both optically and as to control, served the cinema studio from its earliest days up to modern times. Arc lamps are to some extent inescapably noisy. Many arc lamps together are proportionately noisier. When sound came to the cinema the noise of the arcs became a factor to reckon with. When colour film was introduced, at least three times as much light was normally required on the set, making arc noises at least three times as noticeable at first.

Around 1947 'Compact Source' discharge tubes began to replace arcs in certain cinema studio applications. The discharge, in a quartz bulb, was in an atmosphere of mercury to which cadmium and zinc had been added. Five-kilowatt lamps of this kind had excellent colour-rendering properties and in efficiency were comparable with arc lamps. They could not be re-lit for at least twenty minutes after they were switched off, so in off periods they were 'simmered' at 1 kilowatt after which they could be switched to full output at once. Various sizes from 2½ to 25 kilowatt rating came rapidly into service. Later a system of high-voltage, high-frequency impulses to switch on a completely extinguished lamp while it was still hot gave a less awkward form of instantaneous control.

Discharges in Xenon and Krypton gas under high pressures also provided a light of excellent colour-rendering properties and such lamps were introduced about the same time as compact source lamps, with which they shared the advantage of silent operation.

All these new ideas faltered before the competition of the carbon

arc which had been tamed into a condition of severe controllability by so many decades of profitable application. Just as it seemed that the new techniques might succeed by a balance of inherently good properties against difficulty of control, the makers of photographic film developed a new emulsion which demanded, for colour photography, the tungsten filament heavy duty lamp. The technical aspects of this development included a sensitivity demanding only a quarter the brightness that was previously essential. The present balance (1957) is arc versus tungsten, with other devices very much on the fringe of the picture.

Still Photography

Photography is a relatively new subject that has benefited by various lighting techniques although it is probable that increasingly sensitive media developed by the photographic chemists have more profoundly influenced photographic techniques than any developments in the lighting field. At first strong sunlight was the best light for the photographer and the long exposures needed for any indoor work demanded equipment such as head rests and postures that make the subjects look comical to our modern eyes. Flashlight photographs were at first taken by blowing magnesium powder through the flame of a gas jet. The apparatus for doing so, described in a photographic encyclopædia of 1892, consisted simply of an insufflator with a long brass tubular outlet. A long, narrow tin tray on top of a handle containing an electric battery provided another means of getting a flash. Magnesium powder was spread along the tray and ignited by the battery. Later magnesium ribbon provided a handier but slower device which was admirable for exposing prints but limited in its application to negatives. Magnesium made an unpleasant white smoke of oxide that settled everywhere within range after an initial semi-explosion that projected it at the ceiling. It was by no means an admirable medium, but it produced results. The results were usually harsh-shadowed so that the subjects looked curiously lifeless, like butterflies on pins.

In 1930 the smoke and danger of fire was removed from the process by the introduction of the photoflash bulb, an ordinary electric lamp bulb containing magnesium foil ignited by a dry-battery operated filament. The cost of these bulbs was rather high, but they were unobjectionable to those who had opposed firmly the use of the open flash. In spite of their cost the magnesium powder flash quickly became obsolescent.

About 1948, following work on microseconds flash tubes undertaken for military reasons during the 1939–45 war in Europe, a microseconds flash-tube kit for photographers was put on the market. The disadvantage at first was the very high voltages required for operation, even though the tubes themselves might give thousands of very bright, almost instantaneous flashes without replacement. Tubes working at voltages as low as 150 volts have since been developed and it would seem that the use of magnesium will soon be a thing of the past.

Still photography has benefited from cinema studio lighting techniques for studio work where projector lamps are used in preference to the news photographer's flash lights. In earlier days the Cooper Hewitt mercury vapour lamp of 1900 proved admirable for the professional photographer in spite of its very poor colour-rendering properties. About 1904–5 Moore tubes were bent into grid-iron shapes to provide 'photographic windows', giving a less harsh light for the portrait photographer. A tube 50 feet long would be bent to fill a panel about 4 ft. by 5 ft. 6 in. The arc lamp, and later the tungsten filament projector lamp, were eventually more successful than either of these devices.

Façade Lighting and Flood-lighting

The theatre or cinema not only required working light but also an attractive entrance. This was recognized quite early, the façades of theatres being lit by candle lanterns and the foyers by chandeliers. Gautier, in his *Journey in Spain* of 1840 remarks that in Vittoria, where the façades themselves were architecturally undistinguished and differed little from other houses, the theatres could be picked out '*pars les deux ou trois quinquets fumeux accrochés à la porte*'. Gas lighting was adapted to the lighting of theatre corridors and entrances as well as the stage, and when electric light came in, the environmental lighting was not neglected. The façade of the National Gallery in London was experimentally floodlit by Staite's arc lamp on November 28th, 1848, but although a vast crowd attended the spectacle it was not repeated. Supplies from batteries were too difficult to manage, but when generating plant was installed at the Savoy Theatre, London, in 1882, it fed 1,158 Swan lamps of which 824 were for stage lighting, 114 in the auditorium and 220 in corridors, passages and boxes. In addition, outside the main entrance, there was a powerful arc lamp supplied from the same source.

The U.S.A., where flood-lighting today is accepted as almost a

commonplace, was by no means receptive in the early years. The dome of the courthouse in St. Louis, lit by stray light from many arc lamps used to illuminate the neighbourhood streets, seemed only an irrelevance in 1884; in the same year 14 arc lamps were deliberately left without reflectors in Washington so that their light would fall similarly on the dome of the Capitol. After a trial period of forty-five days the Commissioners vetoed the scheme.

Moore tubes, about ten years after their introduction in 1895, were made up into lengths of 100 to 200 feet, with provision for renewing the supply of carbon dioxide within them, as the gas

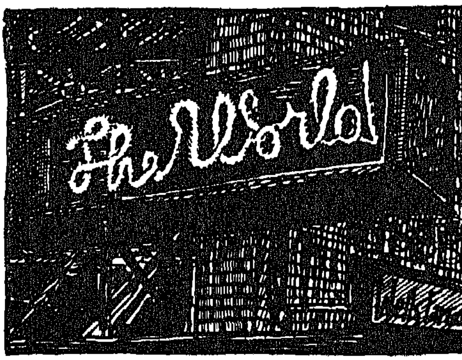


Fig. 46 Moore tube sign, New York City, 1905.

deteriorated after a while. They were operated at a voltage of about 16,000 which in itself demanded precautions against accidental electrocution. Mostly these tubes, which gave a white light, were used for shop lighting, but they pointed the way to the lines of light with which the cinema and theatre canopies were later festooned. They were also used with nitrogen filling, giving a pinkish light, and as early as 1905 they had been twisted into the shapes of words to advertise premises by name. Neon tubes for display, giving the familiar red glow, were first made by Claude in France in 1910, but it was twelve years later before they began to gain such universal favour for advertising and display. Nevertheless in 1913 the façade of the West End Cinema, London, had a large Moore-tube arch supplemented by the name of the theatre in neon. The Grand Palais and a church in Paris had been neon-lit a few months earlier. There are other gases with which different colours can be obtained, but in each case there are economic objections.

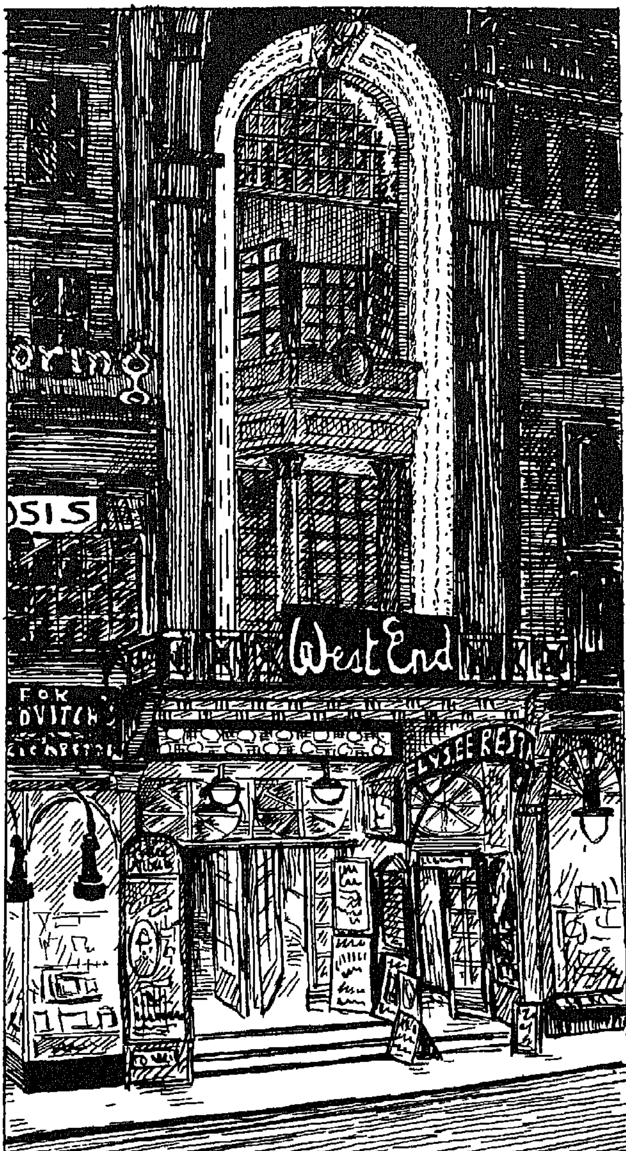


Fig. 47. The West End Cinema, Coventry Street, London, in 1913. The arch outlined by Moore tubes and the name in neon tubing. (Note arc lamps and high pressure gas lamps outside the shop windows.)

The galaxy of colours in which signs have been made in recent years is due to the use of fluorescent coatings in cold-cathode tubes containing the red neon or blue mercury discharges. The emergent colour is obtained from the invisible ultra-violet component of the discharge within, and is virtually unrelated to the colour that would be seen if there were no fluorescent coating. Thus zinc orthosilicate gives out a brilliant yellow light when excited by the very short-wave ultra-violet radiation which is part of the neon discharge. The same material gives out a brilliant green light, twice as bright, when excited by a mercury vapour discharge. The whole subject is highly technical and has developed with great rapidity since the earlier commercial tubes were introduced in quantity about 1935–6. Flashing signs are an old idea. At the National Gas Exhibition in London in 1913 they were even shown operated by gas lamps.

Flood-lighting of façades is another subject of technical complexity. Originally done more or less accidentally by means of arc lamps it was later controlled scientifically using filament lamps and optical projectors. The sodium and mercury hot-cathode lamps of 1932 introduced the possibility of using colour without the very expensive, light-consuming device of interposing colour screens between the light and the building. These colour screens could absorb as much as 80 per cent of the initial light output. Sodium lamps gave a yellow light and mercury, while less efficient than sodium for use directly as a bluish colour floodlight, gave more promise of fluorescent conversion into various colours. Sodium lamps were about three times more efficient as light producers than filament lamps of the usual floodlight sizes (250–1000 watts), but when the further absorption of colour screens was taken into account the relative efficiency became about $4\frac{1}{2}$ to 1. Other colours, such as red, light blue, light green and dark green could be produced, using mercury lamps, between two and three times as efficiently as the filament lamps and colour screens.

Flood-lighting is a subject upon which public opinion is divided. Most people like it, and a minority (in which the author is included, thus explaining what may be to the reader a somewhat disappointing treatment of the subject) are unwilling to generalize. The light comes from the wrong direction—that is from below rather than above. The buildings take on a theatrical air. The awesome pile of Edinburgh Castle, seen by day, becomes a children's cardboard fort by night. The château of Chenonceaux, which is one of the most breath-taking in France, becomes a stage setting perched above black waters among foliage of improbable green. The grand room of the chateau, 30 feet

or so broad by 230 feet long, with tall windows looking on to the waters of the Cher on either side (the château is built on six arches spanning the river) cannot be seen at all, for the beauty of flood-lighting is another that is only skin deep. A pageant is acted nightly before this truly theatrical background and the sound accompaniment is magnified to a level as unnatural as the lighting; but many thousands flock to see and enjoy the spectacle. The flood-lighting of the châteaux of the Loire and of Versailles has been a great success, but it should be recognized for what it is—an entertainment in the modern idiom. The floodlit office building or factory is an advertisement. As such it is quite acceptable to those who may cavil at the flood-lit stones of history; and the office building may seem both cheerful and attractive. It must

Fig. 48. The Pan-American Exposition at Buffalo in 1900–1. 200,000 lamps required a 5,000 kilowatt supply.

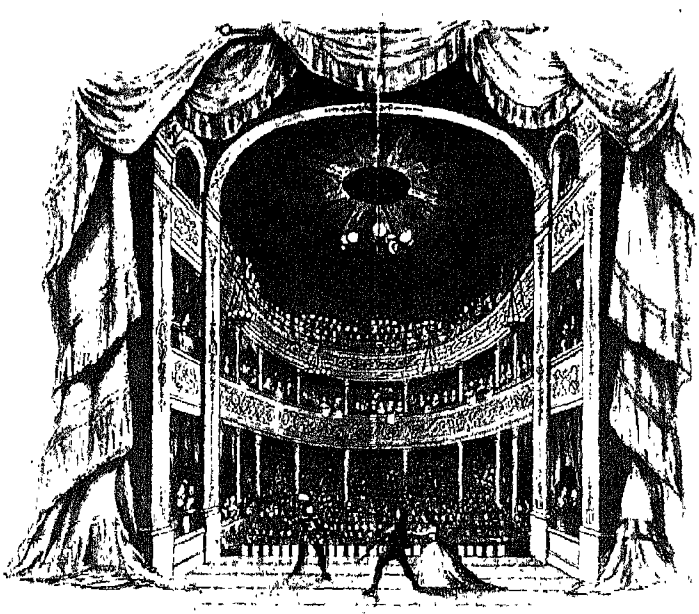
also be admitted that in travelling through France, for instance, one may often see flood-lit exteriors by night of buildings which one would miss by day. It is then possible to be grateful for flood-lighting without necessarily regarding it, as some do, as an improvement on the daylit scene. It can add something, and if discreetly done need take nothing away. The economics of the subject are a different matter. The best economist is the most natural cynic.

Flood-lighting for gala occasions, in which may be included exhibitions, has every historical justification. One of the most successful enterprises of recent times was the large-scale flood-lighting of London town and river on the occasion of the coronation of Queen Elizabeth II in 1953. Such details as the lighting of the coronation arches in the Mall near Buckingham Palace were brilliantly successful. In the exhibition field the competition is such that every new venture attempts to improve on the lighting of the old. For simplicity on the grand scale it will be difficult to beat the Pan-American Exposition of 1900–1 at which 200,000 filament lamps of 8 candle-power each were used

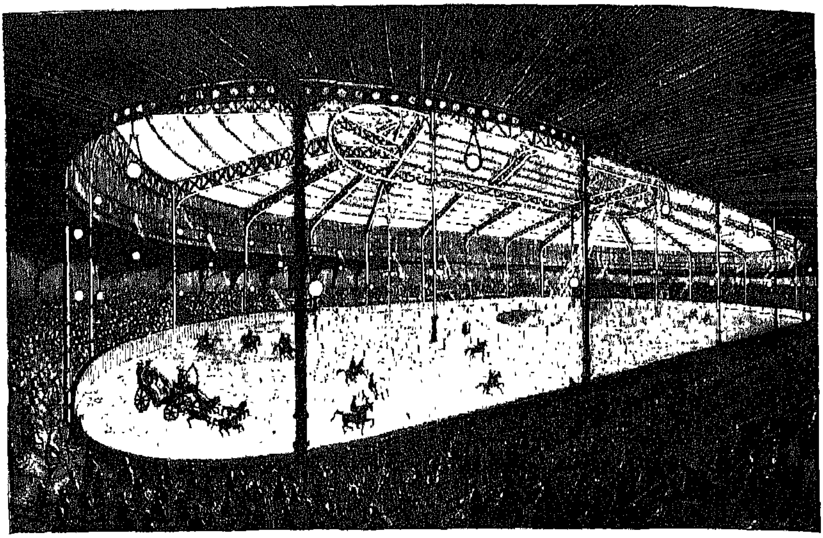
to define the buildings in what was at that time a blaze of light. The Paris Exhibition a year before was also remarkably well lit.

Personal considerations also apply to street lighting. The experts work out economic sums and point to the marvels of sodium and the lesser marvels of mercury. We are told that colour is unimportant for the night driver sees an obstacle, human or otherwise, preponderantly in silhouette against the illuminated surface of the road (unless he has his headlamps on, which is incorrect on such a roadway). All that may be true, but while it is possible to stretch a point in favour of mercury, as it is not too unlike moonlight for toleration, sodium gives a distressing monochromatic yellow light that has no natural or historical counterpart to persuade us into accepting it. One day we may find that long familiarity has persuaded us at last; but before that time comes it is probable that fluorescent lighting will have made us still less willing to sacrifice colour at night. Meanwhile City Fathers, even in pleasant towns, continue to save their citizens a penny in the pound at the price of illumination jaundice after dark, and to present their historical buildings in shapes and colours that the architect never intended. The architect of the future may have to design for night as well as day.

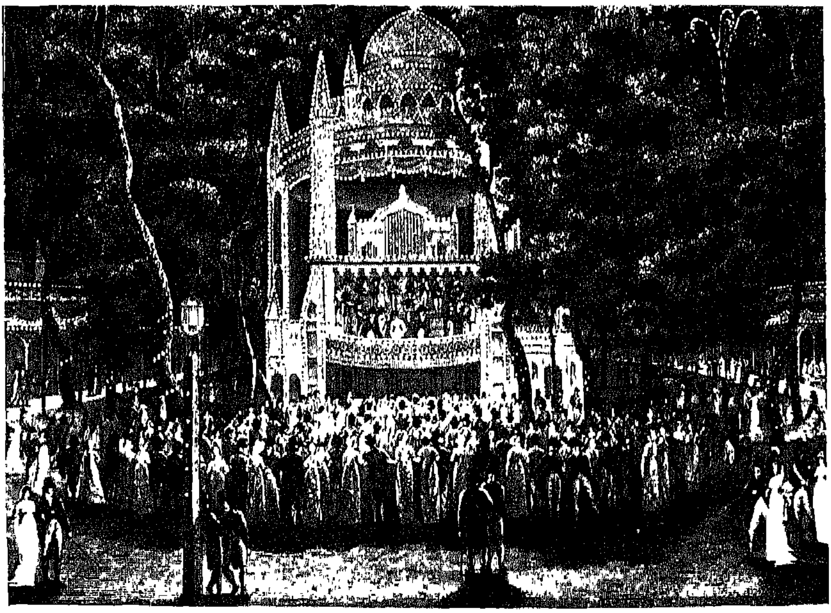
Candle-lit drop curtain (Comédie Française, 1826)



Theatre Royal Mary-le-bone, showing gas lighting, mid 19th century



The Paris Hippodrome lit by Jablochkoff Candles, 1880



Vauxhall showing outdoor illumination, 1804

CHAPTER VIII

Light for Gaiety and Great Occasions

LIGHT for church festivals and for the theatre has been dealt with in other chapters, while light for ordinary occasions has two chapters to itself. It is difficult to draw a hard and fast line of demarcation but there seems room for a section, however disorderly, describing numbers of the more ambitious attempts to defeat darkness, both outdoors and in. Early records, other than those relating to religion, are extremely sparse and there has been found little of note before the disastrous '*Bal des Ardens*' in the time of Charles VI of France.

LIGHTING OUT OF DOORS

Don Quixote's arrival at the village where Camacho and Quitera were to be married was at nightfall and the scene was as though that of a sky filled with countless shining stars. There was no wind to disturb the myriad of little lights placed in an arbour of trees erected at the entrance to the village. The '*Flambeau du Jardin*', an inverted, elongated, bell-shaped glass globe to shield a candle in a holder from the wind, was known in France at least as early as the 17th century, but the design seems to have been confined to sophisticated, and therefore expensive and not too numerous examples.

It was in the next century that the garden fête developed into something quite lavish in scale. At Herrenhausen, for instance, in 1741 the Duke of Brunswick held a fête by the light of simple float-wick oil lamps (Plate 26*a*). The unknown artist who depicted the scene shows at least 5,000 of these and there may have been many more outside the area of the picture. A quiet night, free of wind and rain, would appear to have been an essential. The same ingredients of success may be specified for similar outdoor functions today, despite the advantages of modern weather-proof lighting. It is not, therefore,

so incongruous that the Duke should have let his party depend on such vulnerable sources of light. Napoleon III, in 1852, was not so lucky in the celebrations for the re-establishment of the French Empire. Paris was to have street festivities, with the main squares and boulevards illuminated 'on the grandest and most brilliant scale'. Unfortunately 'the wind interfered most rudely and recklessly'. The oil lamps suspended from rings encircling Trajan's column in the Place Vendôme were either blown out or burned 'only fitfully and ineffectually'. Even the gas lighting, which was a feature of the scheme, proved to be a great disappointment. The quotations are from the *Illustrated London News* of the day, and it is clear that a populace determined to be gay was defeated in the end by winds and rain against which the illuminations could not hope to succeed.

The first use of gas lighting for an outdoor celebration was probably in St. James's Park, London, in 1814, when many visiting sovereigns came to celebrate 'The Peace of Europe'. Nevertheless this same fleeting moment of 'peace' presented to an enterprising solicitor in Sheffield, Yorkshire, an opportunity to decorate the front of his office premises with an illuminated sign consisting of a star and the words 'The Peace of Europe' made up from over 1,300 iron spout-wick oil lamps attached to suitably fabricated iron frames. One letter 'H' from this sign is exhibited in the Science Museum, London, and may well invalidate many later claims to have been the first with signs made up of illuminated letters. *The Times* of 21.5.1856 described 'The Horrors of Peace' in the following terms:

'I have not met with a single person in society who has not spoken of the illumination of private houses as a nuisance, which no one would incur if it were not for the fear of a stone through his drawing-room window.

'Without wishing to be sentimental, or to shelter myself under a plea which I fortunately have not to plead, the many houses in which there may be sick, dying or dead inmates ought not to be left out of consideration.

'But I rest my appeal on the absolute nastiness of smoke, grease, and gas in unusual proportions, and in places not made for them about every house. I agree most willingly to pay my share in the cost (whatever fraction of a halfpenny may represent it) of the public illuminations. I am perfectly willing, if any public or parochial boards will undertake to exhibit supplementary fireworks or transparencies in the open spaces of each quarter of the town, to be rated or to

subscribe for that purpose also; but I object, with all my heart, to be coerced into a piece of domestic dirt and discomfort by the terrorism of glazier and gasfitters.

'Beyond the benefit which these two particular callings may be able to extract from the apprehensions of the public I see no possible enjoyment which any human being will reap from the illumination of private houses. To the spectators it will be dingy, to the occupants a nuisance. But I can see one great public evil in it. If we are ever unhappily engaged in war again, the whole of the middle and professional classes will have contracted that dread of peace which will make them cry as one man and for ever "On with the war!" . . .

Mr. (with the consent and approbation of Mrs.) GLASS.'

In 1889 the Eiffel Tower carried 4,000 gas jets on its spandrels and the three platforms. For another exhibition eleven years later the whole tower was outlined by 4,000 10-candle-power electric lamps in paraboloid reflectors.

In London, from the mid-18th century onwards, there were permanent garden entertainments such as those in Vauxhall Gardens and the Cremorne Gardens in Chelsea. They catered, variously, for the gentry and for the lower stratum of society, but apart from special daytime occasions such as balloon ascents, they relied for their custom on the provision of band, singers, dancing and the sale of refreshments. There might well be a fireworks display to round off the evening but the bread-and-butter part of the proceedings centred on the band. This was illuminated by crude, thick-wicked oil burners with large glass globes to protect the flame from the wind. Float-wicks in deep glass jars, probably tinted, provided additional lighting strung around the trees of the 'illuminated walks' and the bandstand (Plate 24*b*). Similar lamps, fairly resistant to the wind, or candles adorned the tables, but these had to be paid for. A bright moonlit night must have provided a welcome addition to the rather uncertain and feeble illumination that could be provided by man, and on any night the attendance was largely governed by the state of the weather.

Many 'wax lights' were short stubby candles of the 'night-light' variety burning at the bottom of glass bowls to protect the flame from the winds. In these lights, after a time, the wax liquefied completely so that they became, in effect, oil lamps. At Vauxhall, however, ordinary tall candles seem to have been used to supplement the inadequate light of the oil lamps used for general lighting (Plate 25*a*). The cost of the evening, with orchestra, singers and fireworks was

increased by the entrance fees to the gardens; but beer, rather than champagne, was called for by the less affluent.

A bill for a supper in Vauxhall Gardens, found among old family papers, was given by J. B. Booth in *London Town* (T. Werner Laurie, London, 1929):

Champagne	13/-
Wax Lights	1/6
Table beer (quart mug)	6
A pulled chicken	4/-
A tart	1/-
A biscuit	1
	£1 0 1[1]

At the Royal Surrey Zoological Gardens, on August 5th, 1839, the 'Kinophostic' light or 'lime light' was advertised as 'a chemical combination of such intense brilliancy and diffusiveness as completely to illuminate the whole gardens by ONE CENTRAL LIGHT!' A year later the same effect was described as one 'which from one small lantern on the tower of the glass conservatory will diffuse the radiance of the brightest moonlight over the whole gardens'. There are many records of this light but it proved not a little troublesome to maintain out of doors and its future lay mainly in the theatre.

Float-wick lamps in deep glass jars (such as those still common in sanctuary lamps) were used by the hundred or even by the thousand for private parties. The jars might be tinted in various colours and the garden part of the fête might be no more than an extension of the party from a candle-lit ballroom. Not much detail and practically no colour could be seen by their light, but they looked pretty. Even in the better-lit ballrooms colour had to be crudely vivid for effect. the 16th-century John Heywood realized that 'at night all cats be grey' and delicate shades of colour were hardly discernible. Aniline dyes did not apear until the second half of the 19th century and before that colours were both limited in range and usually far from fast. Coloured lamps, therefore, whatever their shortcomings as illuminants, did at least add colour to a scene that otherwise tended towards drabness. Wax 'nightlights' in glass jars were being used extensively to light outdoor parties well before the middle of the 19th century.

[1] In those days 1*s*. equalled 24 cents.

The pleasures of London, as a metropolis, were sophisticated compared with most. The bonfire still provided illumination for village festivals (and still does on Midsummer Day in France, where the addition of fireworks as in the British Guy Fawkes Day [November 5th], seems not to be popular). For peasant festivals in Northern Italy a thousand snail shells may still be seen, set in clay, burning crude olive oil or fish oil through fibre wicks. In Japan, a cloud of fireflies was released as the culmination of an evening party. In India, as at Herrenhausen, a great number of open saucer lamps were, and still are, used but with tea oil as the illuminant. Weather remained always a dominant factor and moonlight was ever an excellent support to the limited light that lamps could give (Plate 26*a*).

From the 1880s onwards electric lighting has provided a more brilliant and more certain medium for the gala occasion. There is little point in trying to trace in detail its applications which in general derive in technique from other developments, but a quotation from *The Illuminating Engineer* of 1913 shows that it was not without rival. Talking of acetylene flares it was said that 'lamps of this kind have very frequently been used for garden parties, fêtes, etc. (e.g., to enable bowls to be played by night)'. Four such flares, burning 12 lb. of carbide each in six hours, were required for every 1,000 square feet. Naphtha flares were similarly used, although they were less effective.

The strings of coloured lights that are threaded through trees and round bandstands are in the direct tradition of the 18th century. Neon lights, fluorescent tubes, floodlight projectors and moving signs are outward manifestations of technical competence. Variations on a technical theme are a technician's business and their interest is not for the lay reader. Let it suffice to say that one seaside town in England, Blackpool, spends at least £75,000 every year on illumination designed to attract the crowds from industrial Lancashire for a few weeks at the end of the season. This may not seem a great sum compared with what is spent to animate or illuminate New York's Broadway or London's Piccadilly Circus, but this is not part of the mysterious business of spending otherwise taxable money to bring a trade name before the public. It is, in the case of Blackpool, just a great annual party in which the gaiety of the lighting has to persuade the guests to come and enjoy themselves at a time of year when neither season nor weather would normally be regarded as propitious.

INDOOR OCCASIONS

Apart from the torchbearers to whom reference has been made, the early lighting of great occasions was mainly by candle. White wax, which was at least 10 per cent dearer than yellow wax, was preferred and the quantities might be quite considerable. Thus, in 1549, for the baptism of Louis, Duke of Orleans, there were:

For the tabernacle where stirs the infant	2 flambeaux of white wax each of ½ lb.
Great chandeliers of the chamber	14 flambeaux of 1 lb.
Table of offices	2 do.
Grand Festival Room	Lit as usual by candles of yellow wax, each 1 lb.
Buffet	24 of white wax, each 1 lb.
Archers	100 torches of yellow wax.

In all there must have been about a hundredweight of wax to burn. This was lavish. There is a record of 1595 at Lyons in which there were only 4 flambeaux of white wax '*pour allumer et esclairer pendant le bal*'. Each flambeau weighed 2 lb.

These long candles would burn for many hours, but unless they could receive attention periodically some of them would gutter and smoke, the wax would run down, and if chars were allowed to burn or if there were so many candles they bent over from the heat the results could be disastrous to the folk below on whom would fall a rain of molten wax. Wax guards were simply metal discs, usually ornamental, at the foot of each socket. They could cope with an ordinary overflowing of wax, but with no more. The Order of the Golden Fleece at Antwerp in 1455 had a great two-armed candelabrum holding 48 candles. A contemporary drawing shows a pair of 10-runged ladders standing below so that attendants could get up to snuff the lights at intervals. Many chandeliers were so arranged that they could be wound down to floor-level when attention was required, but protocol would demand no such expedient in the middle of the solemnity of many great occasions or the rigid convention of others. A counterweighted sliding chandelier is shown as early as 1450 in a panel by Petrus Christus of Bruges now in the Atkins Museum, Kansas City. Wax candles were very much better than tallow in that they might last several hours before attention became a desperate necessity, a stage reached long after attention first became desirable.

An example as late as the crowning of George IV in London in 1821

will illustrate the point. For the occasion there were in Westminster Hall 28 glittering lustres, each holding 60 candles. The heat was such (possibly because it was a July day) that many of the ladies fainted. The wax melted before the candles were even lit and, aided by a draught of air, ran down eventually to such an extent that it overflowed the wax guards and fell on to the people below, ruining many

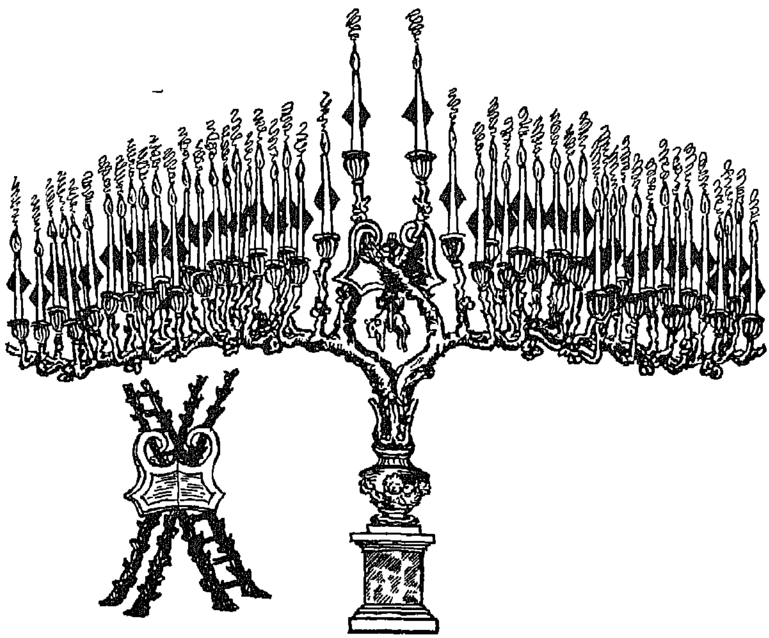


Fig. 49. Candelabrum of the Knights of the Golden Fleece, Antwerp, *c.* 1450.

of the magnificent dresses. Perhaps nothing could be found more aptly to show that the candle, up to the introduction of the snuffless wick, could not be regarded as trouble-free unless attention could be given at frequent intervals.

Coronations of the Georges in England seem to have been remarkable for such incidents. In 1727, at the crowning of George II, 4,000 wax tapers were said to have been lit in less than a minute. There is no clear record of how the feat was accomplished, but at the coronation of George III in 1761 the lighting of 3,000 candles within half a minute was accomplished in a spectacular way. The candles were all linked up by trains of 'prepared flax'. Presumably the preparation was by impregnation with gunpowder to make a very quick fuse.

The coronation procession groped its way into the virtually unlit hall and the members found their places after much confusion and difficulty. Then, at the moment the royal party entered the hall the train of fuse was set alight. The effect was stupendous. The candles were truly lit within half a minute, but nobody had much time to enjoy the effect nor to admire the royal entrance. They were much too busy coping with the rain of fire from the fuses that descended upon them from above, covering them with sparks and threatening to set their finery alight.

For more ordinary occasions there is evidence in many pictures and prints. A picture painted by Francesco Guardi in 1783 is of a Gala Concert in Venice (Plate *26b*). The long candles burn evenly in chandeliers and sconces and there are about 50 of them in a room large enough for an audience of over 100 with 33 musicians and singers in the gallery. In the original picture (in the Alte Pinathotek, Munich) the colouring by this modest light is fairly sombre. The ceiling rightly gets more light than the gathering below. It is too much to expect that an artist who was probably commissioned to depict the scene should show it after the candles had possibly guttered into ineffectuality, or alternatively should show the rather incongruous intervention of a snuff-boy to attend to them. If the concert lasted only two or three hours and the candles were of the best wax, there may not have been any trouble at all.

About the same time, in London, there was a notorious establishment called The Dog & Duck (Plate 29). The ladies parading in the central space between the tables for refreshment may for a time have lacked companionship, but among the crowds of men present they expected to meet somebody they knew, or could know. To light the parade two chandeliers each contained 16 candles by the light of which the charms of the ladies might not pass unnoticed, and perhaps their imperfections might not be overstressed. There were also 8 or more pairs of candles in wall sconces so that the atmosphere of the place must easily have become a little thick. To cater for this, above each chandelier, there was a large hole in the ceiling through which hot air and smoke from the candles could escape.

The problem of heat and smoke was a real one. In 1831 Cruikshank drew the scene in the ballroom of Almack's in London. This was a fashionable and exclusive club. There are two chandeliers with a couple of dozen candles in each and numerous wall sconces each containing two. Allowing for the large part of the room outside the picture there may have been up to a couple of hundred candles

burning. The heat from so many small fires is far from inconsiderable and even at this late date some of these candles would almost certainly smoke badly and even gutter if they did not receive attention. In another decade or so the snuffless wick would have obviated this need, but by then the candle had to meet still greater competition from gas lighting. (Plate 17*a*.)

The masquerade or carnival was a popular entertainment, usually held at some theatre. Two such, at the Opera House, are illustrated by Cruikshank in the same publication. In each case there are glass float-wick lamps by the hundred in addition to the usual candelabra and what may be either gas or oil lamps. A more sober representation of a similar fancy-dress revel on the stage of the Haymarket Theatre in 1724 shows the scene lit by 13 coronas containing a total of nearly 120 candles while another couple of dozen or so are to be seen in wall sconces. In all these cases the heat and smoke of the illuminations must have become very noticeable after a time. At a gala in the Tuileries to mark the marriage of Leopold I a canvas by Athalin in the Carnavalet, Paris, shows as many as 1,200 candles alight.

One ambitious attempt to replace candles by gas lighting took place in the Chamber of the House of Commons, London, in 1838. An excellent account of the proceedings was published in *The Times* of February 13th of that year and is quoted below:

'It was now nearly dark, and the process of lighting up the House with gas being slow, it became difficult to take notes in the gallery, not only on account of the absence of light, but the attention of the members generally was diverted from the proceedings of the House to the novel experiment about to be tried; a confused murmur of conversation prevailed, and consequently those members who rose to address the House at this unfavourable period scarcely obtained a hearing. In order to understand the nature and effect of the experiment, it is necessary to state that there are two ceilings to the House, the original flat lath and plaster one connected to the roof, and an additional one, placed some few feet below it, which was introduced about eighteen months ago, when several alterations were made with a view to improving the ventilation of the House, and to assist the hearing. This second ceiling is composed of a wooden framework, in three divisions running lengthwise, forming, as it were, three sides of an octagon; the two compartments next to the walls are glazed with ground glass, and equal to the whole length of the building, standing in a slanting position, and supporting the third division which

is merely a wainscoting, flat, and about the same width as the others. Immediately above the two glazed divisions three gas pipes were placed, being perforated with holes about two or three inches apart, for the purpose of throwing out as many jets of gas, the ascent of which to the height required was not very rapid at first, and the tapers were passed over the apertures several times before ignition took place. This was effected, first of all, at the lower end of the House, directly over the gallery appropriated to the accommodation of "Stranger", making them unusually conspicuous and observable to every member, in spite of the standing order. The persons engaged in the operation proceeded to the other end of the House next, and after a few trials succeeded in lighting the gas over the reporters' gallery, from whence the brilliant illumination gradually extended over the three rows of jets, until the whole House was in a blaze, agreeably with the motion of the Hon. member for Finsbury. The effect was charming to the eye; the light shining through the glazed ceiling, rendering it exceedingly soft and mellow, although twice, or perhaps thrice, as strong as the light given by the candles, which were still mounted in the chandeliers, but not lighted. A great heat, as might have been expected from so much gas burning, is felt by those who sit in the galleries; and as there is certainly more light than may be required for ordinary purposes, it may be worth while for those who manage the affair to consider whether two rows of gas pipes may not be sufficient for the purpose. As far as we could learn the experiment gave very great satisfaction to the House.'

But on the following evening lighting by wax candles was resumed in consequence, it was stated, of the great additional expense of the gas.

The fact that the gas light could be used to assist ventilation by directing the products of combustion into flues discharging into the outer air was the subject of a British Patent by Riddell in 1817. This principle was employed in a much more successful arrangement for lighting the Chamber of the House of Commons by 64 Argand burners, in 1852. These burners (no doubt renewed from time to time) continued in use up to 1900, an exceptionally long life of forty-eight years being an indication of the satisfaction given by the scheme. They were not installed without opposition and Sir F. W. Trench, who later had the grace to admit that they gave a very pleasing effect and greatly improved the ventilation of the chamber, was one of those who, made wary by the imperfections

that soon showed in earlier schemes of pierced iron jets and variable gas supplies, campaigned against the proposal. In a letter to the *Morning Post* in 1852 he wrote:

'Here is a brilliant but distant prospect of what is called instant relief from the sufferings inflicted on the luckless Members of the House by the united wisdom of the architect and the philosophical ventilator. I confess this high-flown philosophy is quite above my comprehension; and, in the name of common sense, I venture to exhort the Members of the House of Commons to return to the Gentlemen's light of good wax candles, for which, in auld lang syne, I so earnestly contended, in spite of ridicule that attached to a question of long threes or short threes; and if no tricks are played by interested parties, I firmly believe that lustres, well filled with good wax candles, with handsome shades, in Mr. Barry's best taste (green without and paler green within), would afford a pleasing and more efficient light to those who are engaged in business in the body of the House, and an agreeable repose to those who lounge in the gallery; not forgetting that allotted for the listening public, or the very important eyes of the reporters, or those brighter and more interesting sparklers which are sometimes ranged in cloistered obscurity above and behind the reporters' gallery!'

In the same year the pierced iron jet, which would last without serious deterioration for at least some days or even weeks, was regarded as adequate for the task of outlining the nave of St. Paul's Cathedral in lines of light on the occasion of the funeral of the Duke of Wellington (Plate 30) St. Paul's became, through the unremitting labours of an army of workmen, a vast grandstand with rows of gas pipes feeding close-set jets of brilliant flame along the entablature of the columns flanking the nave. It was a *tour de force* that contrasted strongly with the decision, a year before, to open the Great Exhibition in the newly-built Crystal Palace only from May to the end of October because of the difficulty of lighting the vast exhibition halls after dusk. The lighting of St. Paul's for the great occasion was in keeping with earlier tradition. Elias Martin, in his painting of the late 18th-century christening of the Duke of Södermanland in Sweden, shows the church similarly lit, but with rows of hundreds of large candles set to burn at the same convenient column-top height.

By 1872, when Gustav Doré illustrated a ball at the Mansion House (Plate 13*a*) in London, the lighting was from crystal gas chandeliers

fitted with a regulator such as those used for street lighting, to ensure absolute uniformity in the flame.

The advent of gas by no means did away with the usefulness of the candle. A charming scene painted by Wallander in 1861 is shown in the National Museum, Stockholm. It is of Ulla Winblad dancing the minuet in the rooms of a country house lit by a central chandelier with four fat wax candles, and some wall sconces. Colza oil lamps of the Argand type were also used to light the dining-halls and ballrooms but relatively little favour seems to have been gained by the paraffin lamp as a festive illuminant. They were used, of course, but not on the scale that might have been expected from their popularity in other applications. Perhaps it was the fear that they might be upset if a party became too boisterous, for although they were safe enough in the ordinary way, a pool of burning paraffin is a nasty thing to deal with.

Electric light had many advantages for occasions great and small, but it can scarcely be said that it swept all before it in its earlier days. At the coronation of King Edward VII in 1902 seven electric lamps were installed in Westminster Abbey 'to assist the photographers'. At that time large carbon-filament lamps were being made in sizes up to several hundred watts; but even if these seven were of the largest sizes they can hardly have given more than a modicum of assistance over a very restricted area. At the crowning of George VI in 1937 there was already a television service in London to demand a light of 30 candles per square foot over a small area of the Abbey and 15 candles per square foot elsewhere. This was achieved by means of batteries of high-powered projector lamps casting hard shadows and causing discomfort from their heat as they beat down from above upon the participants.

In 1953 colour films were taken and the television transmission from the Abbey was most elaborate for the crowning of Queen Elizabeth II. The lighting experts of the British Ministry of Works. this time rejected cinema studio techniques and lit the whole area by 500, 750 and 1,000-watt tungsten filament projector lamps at 30 to 60 feet above floor-level, so trained that the pools of light they cast intermingled to provide an overall intensity of 120 candles per square foot, with every position lit from four different angles to ensure that nowhere should there be harsh shadows; it was found that these relatively small units cooled themselves so easily that after half an hour's test the ambient temperature rose only by two degrees. On the great day the weather was unseasonable for June and if there was any

complaint it was not that the Abbey was overheated. The total lighting load was 300 kilowatts.

LIGHT FOR SPORT

It is obvious that with the lights of earlier days there can have been nothing spectacular in the sporting line once darkness had fallen. A chessboard could be lit by a single candle, but of the more energetic pastimes the cockpit and the billiards table seem to have been the limit. A picture of a cockpit drawn in 1821 (Plate 31) shows a single corona to hold 24 candles as the lighting immediately over the ring. The Westminster Pit in the same year had 12 candles with a reflector above arranged round a central corona and 6 sconces, each bearing 3 candles behind which was a reflector, arranged around the ring. The 'sport' at this ring seems to have been varied by contests between a monkey, 'Jacco Macacco', and any challenging dog of up to 20 lb. weight. The monkey, even if not unscathed, seems always to have won.

For billiards, about 1770, a rectangular frame about the same size as the table, is suspended from the ceiling (Plate 31). A couple of candles in metal holders are fixed to each of the four sides. In billiards it is necessary to have highly directional lighting to shadow and thus give substance to the balls. The lighting of a table today is therefore very little different in principle from that in the time of Diderot, and fluorescent lamps, for instance, are of no use at all.

Astley's Circus in London was more a spectacle than a sport. It was lit by 1,200 oil lamps of the float-wick type in glass containers of various colours. That was about 1780. Seventy-two years later, in Paris, the winter circus was lit by gas. There were over 30 globes in a great chandelier central to the ring and 256 more in 16 chandeliers suspended above the audience. By 1879 the equestrian spectacle, which included racing, had pressed into service the electric arc. The Hippodrome in Paris which had a floor area of 65,000 square feet and seating for 8,000 spectators had 140 arc lamps and a couple of 100 horse-power steam-engines to drive the dynamos that supplied them. Greyhound racing, which began operating in flood-lit tracks about 1927, must concede nearly half a century to this effort as far as pioneering goes.

The flood-lighting of football pitches in Britain came even later and it was twenty-five years after the first greyhound racing scheme that it began to spread rapidly among the major clubs. It is usual to

have at least four banks of projectors on high towers, each of which illuminates the whole of the pitch. Each bank contains between 15 and 20 lamps and the total load for an important pitch is rarely less than 80 kilowatts. The system of lighting from each of the four corners of the ground gives solidity to the ball without introducing shadows of the most confusing kind; but judgment of the flight of the ball is still less accurate than by daylight, and there are certain situations in which at least one of the players going for the ball can be beaten by dazzle before he can play it. The sun can also dazzle, but much can be done by way of orientation of the ground to avoid difficulty. With

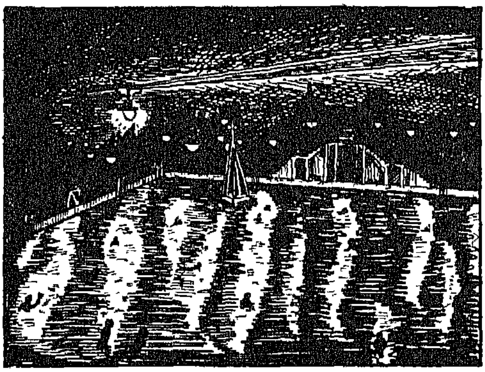


Fig. 50. Delmar Pool, St. Louis, Missouri, 1913. Twenty-five 500-watt Tungsten lamps.

flood-lighting it is more difficult to avoid dazzle and the imperfections are illustrated by the high scoring in flood-lit games. Nevertheless, as a spectacle, the flood-lit football game has much to commend it. At the famous Wembley Stadium in London in 1955 the installation comprised 192 flood-lights 100 feet off the ground, giving 20 lumens per square foot on both horizontal and vertical planes for an expenditure in power of 340 kilowatts.

Arc lamps were early in use for the lighting of indoor sports arenas, but glare and flicker imposed limitations on their effectiveness. At teh University of Illinois, in 1902, the gymnasium was lit by 12 nernst lamps and incandescent lamps were in use below the surface of the water in the swimming-pool.

Swimming-pools, outdoor tennis courts and even a polo field were being lit by tungsten lamps in U.S.A. in 1912–13. The Delmar pool of St. Louis used 25 500-watt tungsten lamps suspended from cables

slung across the water and was reputed, in 1913, to be much better than other installations using flame-arc lamps. The polo field required 48 tungsten lamps of 400 watts each. The first major league baseball game to be played under artificial lights was at Cincinnati in 1935. The 3¼ acres of the Yankee Stadium, New York, were in 1955 served by as many as 1,200 flood-lights to give an even, high intensity illumination. Covered tennis courts at Dulwich, a suburb of London, were lit by 10 high-pressure inverted 'keith' gas lamps in special reflectors in 1911, the illumination being about 3½ foot-candles. Ten tungsten filament lamps totalling 10,000 watts were used at the Rackets Club, Liverpool, in 1913. Floor and surrounds were black so that the white ball should show up by contrast.

Indoor lighting of boxing rings, ice rinks and other sporting arenas is a matter of applying known techniques, using ordinary lamps or projectors for high-intensity coverage. Where projectors are used the same principles apply as in football. The light should come from many directions and the whole playing area should be completely covered from each direction. In the boxing ring artificial lighting is particularly effective as dazzle is almost an impossibility. The boxer, chin on chest, is soon prone if he looks up and usually looks up only when he is prone! The naphtha flares of the boxing booths were cruder than the electric lamps of more sophisticated locations, but as long as the light sources were well above eye-level the boxing rings presented, with the cockpit of old, the easiest of all lighting problems for sport.

CHAPTER IX

Lighthouses

THE idea of a light to guide home the benighted seafarer is one of the obvious developments that must have happened independently and repeatedly in ancient times for the sea has always been unruly in upsetting the calculations of man. Navigation was largely a matter of hugging the shore line and lying up at night or during a storm. Trade between countries separated by great stretches of sea was of a very modest order. In biblical times (Kings I.x.22) there is a record of one such regular trade route:

'Once every three years came the navy of Tharshish, bringing gold and silver, ivory and apes and peacocks. So King Solomon exceeded all the kings of the earth in riches and wisdom.'

Consider the reputation gained by Drake's *Golden Hind*, a vessel about the size of an average tug-boat today, for that brought back what was considered to be an enormous treasure in Elizabeth's time; or of the ships, little or no bigger, that came back from the East loaded with great fortunes, in silks and spices; a successful voyage by a few such ships could become an event in history and the route to the spice islands was largely in sight of land in the early days. The Dutch and Portuguese might prey on the English, and vice versa, while pirates might attack them all without discrimination between flags. A light ashore might mean danger rather than safety. Even the pirates were not confined to those afloat. The wreckers might put out false lights to simulate a harbour entrance to a ship running for shelter before a storm. There was little encouragement to the deep-sea sailor to put his trust in a light.

For a coastwise trade conditions were different. In the Mediterranean, the coastal routes became well-known highways, usually along friendly shores. Light was only required if the unpredictable seas kept the ship away from a known haven after dark. It is usual to ascribe to Homer

(800 B.C.) the first description of a beacon light ashore, but this reference (Iliad, XIX, 375) is very doubtful. Translators from 1720 onwards, when candle lanterns and beacon fires were becoming more common round the coasts of Britain, differ on this point from some of their predecessors. Ogilvy, in his translation of 1669, makes it into the simple reaction of the sailor leaving his friends behind as he sails away. The point at issue is whether the sailor leaving his friends was unwillingly sailing away because he could not get ashore or whether his unwillingness was at leaving his friends behind:

> 'That wondrous work his shield, whose dazzling light
> Full moon out-glittered in the clearest night
> As when at sea a fire a sailor notes
> Rising 'mongst hills from solitary coasts
> Whilst he unwilling sails before the wind
> Leaving his friends and native soil behind.'

There were only a couple of coal-fire beacons in the whole of Britain when Ogilvy made this translation and although Pope in 1720 quite definitely made the fire ashore into a beacon there seems at least room for argument over Homer's actual meaning. There is less doubt about the regularly-maintained fire at Sigeum where there were roads to shelter shipping. This light was described by the Greek poet Lesches in the 7th century B.C. There is a theory that the Colossus at Rhodes (3rd Century B.C.) was in fact a beacon, but this is an unsubstantiated, if possible, suggestion.

The most celebrated lighthouse of antiquity was the Pharos at Alexandria, built in the reign of Ptolemy II (283–347 B.C.). Little is known of this structure. Strabo ascribes the architecture to Sostratus, a friend of the royal family, and describes it as of many stories of white stone. The cunning architect was said by Lucian to have had the ascription to Ptolemy incised in soft plaster with the ascription to Sostratus engraved in stone beneath so that the weather would eventually reveal the more worthy participant in the enterprise. Pliny, on the contrary, said that Ptolemy gave the architect permission to have his name put on such an outstanding achievement. The neighbouring shores were low and the beacon was necessary to guide seamen through the shoals and narrows to the harbour. According to Josephus the fire could be seen thirty-four miles away. This would make the tower 550 feet high, a perfectly possible, if expensive, civil engineering project at that time. There was a rumour that Alexander the Great installed a special mirror (? parabolic) that increased

the range of the light. Whatever the truth, Pliny (Nat. Hist. XXXVI. 18) put the cost at an immense sum, equivalent to £230,000 by one reckoning, and agreed upon as 800 talents by various early writers, but the absence of traces of this structure, destroyed in an earthquake in the 13th century, would seem to make improbable a design comparable with the largest of the Pyramids. There have been conjectural statements that the light at the top of the Pharos was a lamp, based mainly on the use of the word *lampada* by Lucian in his description of how Julius Ceasar was guided by it on the seventh night after leaving Troy. Additional evidence is deduced from a passage in Pliny:

> 'Periculum in continuatione ignium, ne sidus existimetur, quoniam e longinque simile flammarum aspectus est.'

The conjecture is that even at a great distance the light from a wood fire could not be mistaken for that of a star. Nevertheless probability is on the side of the wood fire from nearby supplies of scrub. Pliny records, by the way, that there were also lights at Ostia and Ravenna. The fertility of George Bernard Shaw's invention is the only justification found so far for his suggestion, in *Caesar and Cleopatra* that oil was pumped to the top by means of boiling water.

Other ancient lights are those at Corunna ascribed to Roman times; and a stone lighthouse at Menesthus at the mouth of the Guadalquiver River described by Strabo; at Dover (first half of 1st century A.D.) and Boulogne and other places, there were towers from which the Romans may have hung out cressets, pitch pots or wood fires in iron chauffers, possibly as much for signalling as for warnings to seamen. They also built series of towers of the same kind across the countryside. The land lighthouse was a rarity although there is a late record that a square pillar 92 feet high, surmounted by a 15 foot high lantern, was built in flat country between Lincoln and Sleaford, England, in 1751. As a guide to travellers it seems not to have proved necessary as the lantern was replaced by a statue of George III in 1810. The Roman tower at Boulogne was repaired by command of Charlemagne in A.D. 810. He ordered the placing of lights each night to act as a guide to shipping.

Many place-names derive from the beacon fires maintained there in early times. Thus Fire-ness, a headland on the north-west coast of England has become Furness; Flamborough Head in Yorkshire carried the flames that guided the Danish ships to the extensive permament Danish settlement at Danes Dyke below the Head itself. Other lights were probably meant more as beacons to give warning of the not

uncommon piratical raids of those times, but in 1272 there was at St. Edmund's Chapel in Norfolk a light specifically to help all seamen. At Winchelsea about the same time all ships laden with merchandise that used the port had to pay twopence towards the cost of maintaining lights to guide them. Pitch pots, ordered as beacons in the time of Edward III (1326–77) were not as successful as great wood fires as they were more easily blown out or extinguished by the rain in the worse kinds of stormy weather.

The tower of an early 17th-century church at Collioure on the Mediterranean coast of Roussillon, France, is reputed to have been adapted from a much earlier tower built as a light. Collioure is famed

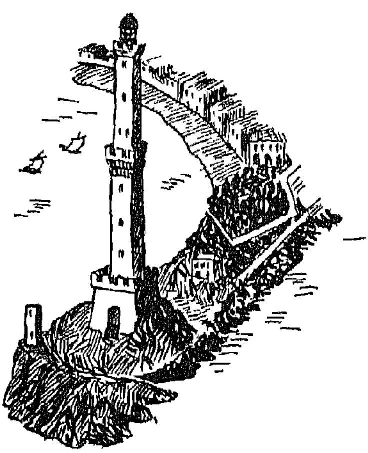


Fig. 51. The 'lanterna' at Genoa at the time of Columbus, *from a 15th-century print.*

as a stronghold of the Knights Templar. At Genoa the tall 'lanterna' now converted to serve as a modern lighthouse, was well known in the days of Columbus and was projected at least two centuries earlier. A tall tower may have been more of an asset as a watch-tower than for a beacon.

The most interesting of the later lights was the tower of Cordouan, a structure 197 feet high, in stone, built at the mouth of the Garonne between 1584 and 1610 on the site of an earlier 14th-century structure to guide shipping to Bordeaux. It was first topped by an oak wood fire. Later in 1727 a coal fire was laid in an iron basket, and a crude reflector about 3 inches deep covered in tinplates in the shape of an inverted cone was added to compensate in some degree for the

preponderantly upward direction of the rays; 225 lb. of coal were burnt every night. In 1780, 80 curved reflectors and lamps were substituted by M. Lenoir, but navigators preferred the coal fires and a temporary return was made to the previous arrangement until, in 1793, twelve Argand burners with parabolic reflectors designed by

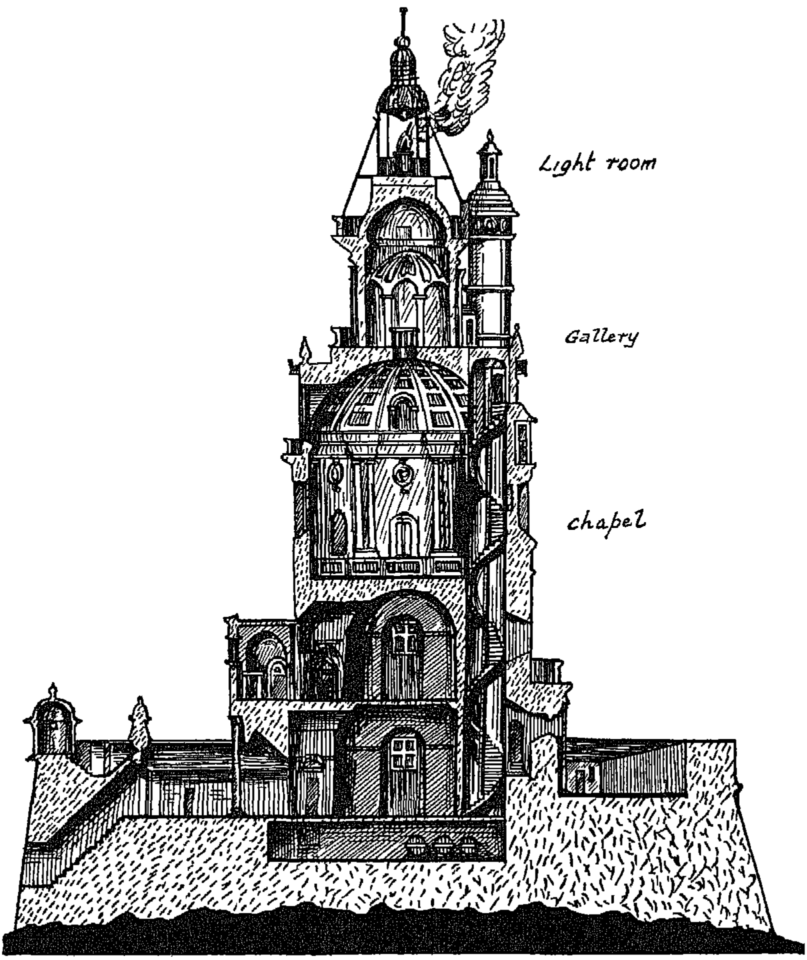


Fig. 52. Tour de Cordouan, 1610.

a M. Teulère were employed. The provision of these beacons was not regarded always with approval. Sir John Killigrew, writing of the light at Lizard Point, in Cornwall, in 1619, remarked that:

'The inhabitants nearby think they suffer by this erection. They affirm I take away God's Grace from them. Their English meaning

is that now they shall receive no more benefit from shipwreck for this will prevent it. They have been so long used to reap profit by the calamities of the ruin of shipping that they claim it hereditary, and heavily complain to me.'

However coal fires were kept going from 1635 to 1816 at the tower erected on the Isle of May in the Firth of Forth, Scotland. Other coal-fired lights around Britain, with their dates of commencement,

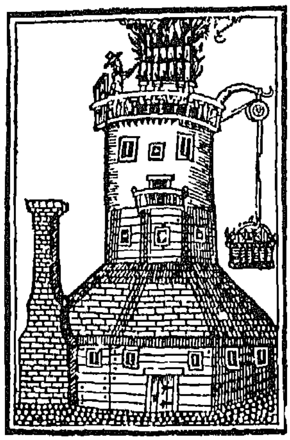


Fig. 53. Dungeness light, 1692.

were North Foreland, 1636; Spurn, 1675; Dungeness, 1692; Harwich, 1707; Skerries, 1715; St. Bees, 1717; Flatholm, 1737; and Lizard, 1751. Most of these were converted to oil during the early years of the 19th century and the tower of St. Bees Head, for instance, which was 30 ft. high by 16 ft. in diameter with four ladders so placed that there should be at least one face free from smoke up which the keeper could carry coal, was surmounted by an oil lamp only in 1822. Before then 130 tons of coal were burnt there in a year; while at the coal light at the Isle of May in the Firth of Forth, double this amount was said to be consumed.

The use of coal fires illustrates clearly the ineffectiveness of other illuminants before the Argand lamp was invented in 1784. Their disadvantages were excellently described in *A New Universal Dictionary of the Marine* in the 1815 edition. At this date they still existed:

'An open coal-fire light, exposed to all winds and weathers, cannot be made to burn and show a constant steady blaze, to be seen at a

sufficient distance with any certainty; for, in storms of wind, when lights are most wanted, these open fires are made to burn furiously and very soon away, so as to melt the very iron work about the grate; and, in cold weather, when it snows, rains or hails hard, the keepers are apt to neglect the fire till it is too low, and then throw on a large quantity of coals at once, which darkens the lights for a time; and till the fire burns up again; and in some weathers it must be difficult to make them burn with any brightness. And when they are enclosed in a glazed close light-house, they are apt to smoke the windows greatly; nor do they afford so constant a blaze as oil lamps, with reflectors behind them; a method now generally adopted.'

The alternative to coal, therefore, before the Argand, was the candle. The Eddystone[1] light was started in 1696 and two years later a light was shown from the top of a 60-foot structure of stone and timber (Plate 32). In calm weather the candles were actually lit in the open air outside the lantern but in rough weather it was found that the waves sometimes enveloped the tower completely, and regardless of warnings as old as Horace that 'towers fall with heavier crash which higher soar', it was raised another 40 feet. In 1703 it was swept away with the designer, Winstanley, and his men. In 1706 Trinity House, the authority chartered in Britain in 1514 for the regulation of pilotage on the river Thames and in 1594 for the control of 'ballastage, beaconage and buoyage', authorized a silk merchant named Rudyard to put up a new structure of wood and stone that was finished in 1708. This was destroyed by fire in 1755. The famous stone structure built by the great engineer Smeaton, was begun in 1757 and finished in 1759. The light used in the lantern, 68 feet above the waves was a two-ringed corona containing 24 tallow candles of two-fifths of a lb. each; 24 oil lamps to the best design of the period were also provided, but they sooted up the panes of the lantern so badly that the candles were preferred as a more practical proposition. Stocks of oil kept good longer than candles, so the lamps were still kept in reserve.

The duties of the lightkeepers included snuffing these candles every half-hour as well as keeping the reflectors and lantern panes clean. In his tours of English lighthouses in 1801, 1813 and 1818 Robert Stevenson, engineer to the Northern Lighthouses (and grandfather to R.L.S.) continually referred to the bad state of some of the lights and reflectors through neglect of these duties. In 1801

[1] Invariably spelt 'Edystone' by Smeaton. The second 'd' seems to have been a later addition.

he recorded that the Eddystone light was still from candles, but by 1813 there were oil lamps but 'the apparatus not in a very cleanly state'[1]

The Argand burner, invented in 1784, made a great difference to lighthouse lamps fed by oil, and was happily just in time for the great increase in the demand for lights to guide trans-ocean traffic as the Industrial Revolution got into its swing. Before then oil lamps had been used with some success in spite of the experiences at Eddystone and Cordouan. The Mersey lights of 1763, for instance,

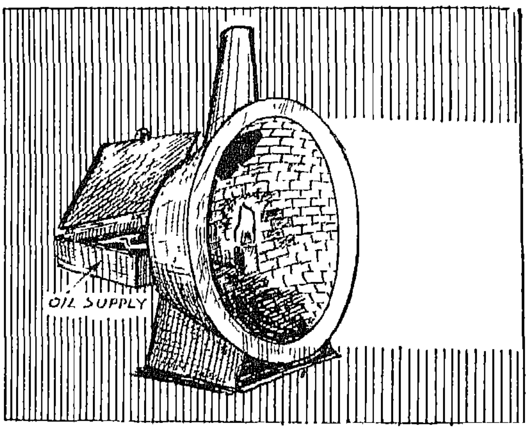
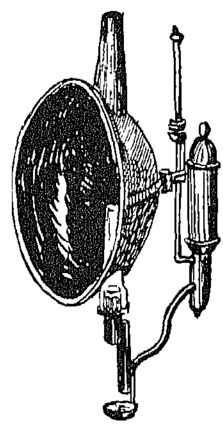


Fig. 54. Whale oil lamp used for the Mersey lights, late 18th century.



Argand burner, 1810 (partly raised for cleaning)

burned whale oil in flat-wicked burners. About the same period, or a little later, there were 16 lights around the coasts of the United States (compared with the 28 round England and others in Scotland founded before 1800), all of which burned whale oil, in a similar manner. The population of the United States, it should be remembered, was then much less than that of Great Britain. Later on the unrestricted slaughter of whales so reduced their numbers that the cost of whale oil became prohibitive and the U.S. Lighthouse Board discovered that both lard oil and rapeseed oil were suitable alternatives, particularly with Argand-type lamps. The Argand burner had a tubular wick through the centre of which a current of air was drawn up. The flame was thus aerated much better so that it burned brightly and,

[1] *English Lighthouse Tours*, edited by D. Alan Stevenson. Thomas Nelson & Sons, 1946.

by complete combustion, substantially without smoke. The provision, of a cylindrical glass chimney completed the aeration process. The flame was of uniform height (compared with the triangular shape of the flat-wick flame) and remarkably constant. It was several times as bright as the flames up to then customary in lighthouses, but even so it was not in itself highly visible at any distance. The light, spilled out in all directions, was being used inefficiently in an attempt to light every point of the compass and every angle of view equally and simultaneously. A very great step forward was to concentrate the light available into a beam focused on the area at which its warning glow was desired.

With coal lights attempts had been made, crudely enough, to cut out wasted light. At Harwich, for instance, in 1801, one of the two fixed lights was a coal fire; the lightkeeper, when necessary, was expected to blow up the fire with a pair of bellows. A flat brass screen behind the fire or a conical reflector above it were hardly good enough to make any very substantial difference. The parabolic reflector with the source of light at its focus was a vastly different proposition. Practical examples seem first to have been described by William Hutchinson in his *Practical Seamanship* of 1791. He described the four flat-wicked lights at Bidstone and Hoylake erected in 1763 to indicate the entrance to the Mersey outside Liverpool. There is, however, a claim that M. Teulère, in France, had proposed such reflectors in conjunction with Argand lamps in a memoir of 1783; if this date is reliable he certainly wasted no time. He also suggested the combination of this improvement with a revolving frame at the Cordouan Lighthouse, but the complete scheme was apparently not effected at Cordouan until Borda and Lenoir installed his system in 1793. Meanwhile, in 1792, a revolving light was made at Lancaster and installed at Walney Island, not far away.

It is difficult to overestimate the importance of these improvements. The beam of light became immensely more powerful and the revolving frame not only helped to distinguish a distant light from the stars but also, from the length of time between flashes, gave a means of positive identification where there was any doubt of the exact position of the ship. Coloured glass was sometimes used to give, say a white flash followed by a red, to make identification even more certain. Many colours were tried at first, but only red survived.

The best reflectors were found to be those made of sheet copper and heavily silver-plated. The frame was made to revolve by means of a weight-operated mechanism not unlike that of some forms of clock.

At the Casquets there were three towers, each with a revolving mechanism, but with no attempt to synchronize them. The resultant effect, far from being more positive, made identification less certain.

The next step was to use lenses as well as or instead of reflectors. Lenses almost antedated the parabolic reflector as they were tried at South Foreland in 1782 and were proposed by a London optician for Eddystone in 1759. The absorption of the necessarily thick but poor glass of the time and the difficulty of figuring a lens that would direct the rays accurately made these attempts unsuccessful.

It was Buffon who proposed grinding lenses in concentric steps and such a lens, cut out of solid glass, was made by the Abbè Roehm about 1780. In 1773, however, Condorçet pointed out that Buffon's ideas could be carried further by building lenses in separate pieces. Sir David Brewster suggested a similar scheme in 1811, but it was Fresnel who, in France, constructed such a lens successfully and placed it in the Cordouan lighthouse, about 1822. It was Fresnel, too, who developed most ingenious systems of lenses to give variable flashes, fixed lights with additional flashes, and so on. With M. Arago he also devised improvements on the Argand burner by mounting several concentric tubular wicks instead of one.

The merits of the catoptric (reflector) system and dioptric (lens) systems can be evaluated in terms of first cost and performance. In simple terms the latter proved to be nearly twice as expensive as a first cost but provided an average effect diffused over the horizon four times as great at about two-thirds of the annual cost. The dioptric system was clearly the better, had it not been for the risk of failure of the complicated concentric multi-burner lamps in which at first, only the non-coagulating spermaceti oil could be burnt successfully. This cost 60 per cent more than common oils before the advent of cheap mineral oil in quantity in the 1860s altered the situation. The early difficulties led to the establishment of such curious alternatives as coal-gas lights particularly in Scotland. Coal gas, in the mid-19th century, was regarded, however unjustifiably, as the panacea for all lighting ills. Even so it is difficult to imagine a more inappropriate site at which to expect a regular coal-gas supply than that of the average lighthouse. The answer to the problem became eventually the electric light or the oil-gas burner with the incandescent mantle; but these developments took some time to mature.

Fresnel's system of lenses for lighthouse lamps is still substantially the basis of the modern light, however complicated it may look. The complication may be more apparent than real, as many of the

components are simply sections of one great lens. The lantern, surrounding the light, and the lenses must necessarily be strong as well as unobstructive. It was therefore usual to make the panes which, in England early in the 19th century, were usually of polished plate glass, $\frac{1}{4}$ inch thick, triangular in shape. There was usually a chimney emerging from the centre of the cap of the lantern although in some cases there was no attempt to conceal the smoke stacks from the living-rooms which crudely spoiled the symmetry of the lighthouse structures.

The ventilation of the lantern chamber itself was a matter of some importance, a long account of Professor Michael Faraday's observations on the subject appearing in the *Mechanic's Magazine* of 1843 (Vol. 39, pp. 236–8). In a winter's night twenty or more pints of oil might be consumed, and for each pint of oil burned more than a pint of water vapour might be generated. In a room 12–14 feet in diameter by 8–10 feet high, with glass walls, the cold air outside caused the water vapour to condense or even freeze. Faraday mentions a depth of $\frac{1}{8}$ or even $\frac{1}{6}$ of an inch of ice to be scraped off the inside of the lantern with knives. His solution was to build up a chimney in sections, each with a conical end into which the top of the next lower section just entered. The lowest section of all had no conical end but was inserted for about $\frac{1}{2}$ inch into the top of the lamp glass. This, he claimed, created a fully effective upward draught while the discontinuities in the chimney enabled a down draught from the outside air to be dissipated into the lantern before it could reach the lamp flame and cause it to waver.

The lighthouse structures themselves could be extraordinarily expensive. The stone tower 138 feet high forming the Skerryvore light cost £87,000 to build from 1838 to 1844. The builder, Alan Stevenson, describes life in the barrack built to house the workmen after the first one had been washed away:[1]

'Perched 40 feet above the wave-beaten rock in this singular abode, the writer of this little volume,[1] with a goodly company of thirty men has spent many a weary day and night at those times when the sea prevented anyone going down to the rock, anxiously looking for supplies from the shore, and earnestly longing for a change of weather favourable to a recommencement of the works. For miles around nothing could be seen but white foaming breakers, and nothing heard but howling winds and lashing waves. At such seasons much of our

[1] *Lighthouses*, by Alan Stevenson. John Weale, 1850.

time was spent in bed; for there alone we had effectual shelter from the winds and the spray, which searched every cranny in the walls of the barrack. Our slumbers, too, were at times fearfully interrupted by the sudden pouring of the sea over the roof, the rocking of the house on its pillars, and the spurting of water through the seams of the floors and windows, symptoms which to one suddenly aroused from sound sleep, recalling the appalling fate of the former barrack which had been engulphed in the foam not twenty yards from our dwelling, and for a moment seemed to summon us to a similar fate.'

The barrack was a three-story wooden cylinder 14 feet diameter inside, with the only the topmost story unencumbered by the pryamid of iron piles to which it was fixed. Stones, some weighing as much as five tons, were washed over the rock, and the force of the waves, measured by marine dynamometer, was at times as high as 6,000 lb. per square foot. It is easy to see how a man might be dashed to death in a stormy sea when it is realized that this figure would, if he were borne with the full force of the waves, mean a 15-ton crash of body against rock. A cast-iron plate over 1 inch thick had a hole 2 feet in diameter stove through it by a wave-borne spar. Even in the month of June, Alan Stevenson was once kept a prisoner by the weather in the barrack for a fortnight on end.

The lightkeeper's duties might not be unduly arduous, but vigilance was demanded. In the rules for the lightkeepers of the Northern Lighthouses, about 1850, there is one categorical instruction:

'The lightkeeper on duty shall on no pretence whatever, during his watch, leave the light room and balcony. Bells are provided at each light room to enable the lightkeeper on duty to summon the absent lightkeeper.'

Alphonse Daudet, in *Lettres de Mon Moulin,* published in 1869, described how the lightkeepers at the Isles Sanguinaires, in Corsica, took a volume of Plutarch with them to the light and read it aloud so that they should keep awake during the monotonous vigil. His account of the light room is admirably vivid:

'*Imaginez une lampe Carcel gigantesque à six rangs de mèches, autour de laquelle pivotent lentement les parois de la lanterne, les unes ramplìés par une énorme lentille de cristal, les autres ouvertes sur un grand vitrage immobile qui met la flamme a l'abri du vent. . . . En entrant j'étais ébloui. Ces cuivres, ces étains, ces réflecteurs de metal blanc, ces murs de cristal bombé qui tournaient avec des grands cercles bleuatres, tout ce miroitement, tout ce cliquétis de lumières, me donnait un moment de vertige.*

Peu a peu, cependent, mes yeux s'y faisaient, et je venais m'asseoir au pied meme de la lampe, à coté du gardien qui lisait son Plutarque a haut voix, de peur s'endormir. . . .

'Au dehors, le noir, l'abîme, Sur le petit balcon qui tourne autour du vitrage, le vent court comme un fou, en hurlant. Le phare craque. Le mer roule. A la point de l'île sur les brisants, les lames font comme des coups de canon. . . . Par moments, un doigt invisible frappe aux carreaux; quelque oiseau de nuit, que la lumiere attire, et qui vient se casser la tête contre le cristal. . . . Dans la lanterne étincelante et chaude, rien que la crépitement de la flamme, le bruit de l'huile qui s'égoutte, de la chaine qui se devide; et en voix monotone psalmodiant la vie de Demetrius de Phalere. . . .'[1]

The fatal attraction of lighthouses to birds has been lessened since by providing perches on which they might alight. More recently the tower itself has been flood-lit. Two 1,000-watt flood-lamps have been found adequate to persuade practically all the birds either to fly around the tower or to flutter upwards in such a way that if they do hit the lantern it is only gently. Nights of low cloud or thick fog presented the greatest danger to the migrant birds.

The 'barrack' described by Stevenson provided an example of a structure built according to one of two great rival schools of thought. It was argued that solid stone was unyielding and unnecessarily expensive because it had to be built so strongly. A structure raised on piles offered relatively little resistance to the force of the waves which could swirl through and round the structure instead of battering against it. The argument, in one form or another, still goes on, but the solid stone tower retains most favour. The Eddystone light built on timber piling was swept away early in the 18th century. The

[1] 'Imagine a giant Carcel lamp with six concentric wicks around which slowly revolve the sides of the lantern—some furnished with enormous glass lenses; others with plain glass windows to protect the flame from the force of the wind. On entering I was astounded. Its coppers, its pewters, its white metal reflectors, its walls of convex glass turning in great bluish circles, all this flashing, all this blinding of lights, gave me a momentary vertigo.

'Little by little, nevertheless, my eyes became accustomed and I went to sit by the lamp beside the custodian who read Plutarch in a loud voice to stop himself from going to sleep. . . .

'Outside the blackness of the abyss. On the little balcony surrounding the lantern the wind blows madly. The lighthouse groans; the sea roars. At the point of the island the breakers sound like cannon shot. Occasionally an invisible finger raps on the windows; some night bird, attracted by the light, breaks its head against the glass. . . . Within the lantern, glittering and hot, nothing but the hissing of the flame, the gurgling of the oil, the driving chain; . . . . and a monotonous voice intoning the life of Demetrius.'

Smalls light, a tiny cramped wooden structure at the top of a pyramid of 15 stout timber piles, stood from 1778 to 1855, but in 1831 the floor and two sides of the living-room were dashed in by the waves and the lightkeepers spent eight days in peril and misery. It is interesting to recall that this curious structure was designed by Henry Whiteside, trained as a maker of violins and harpsichords which, although mainly made of wood, seem hardly akin to an enterprise of massive timber joists.

Fig. 55. (*a*) Eddystone lighthouse in the early 19th century.

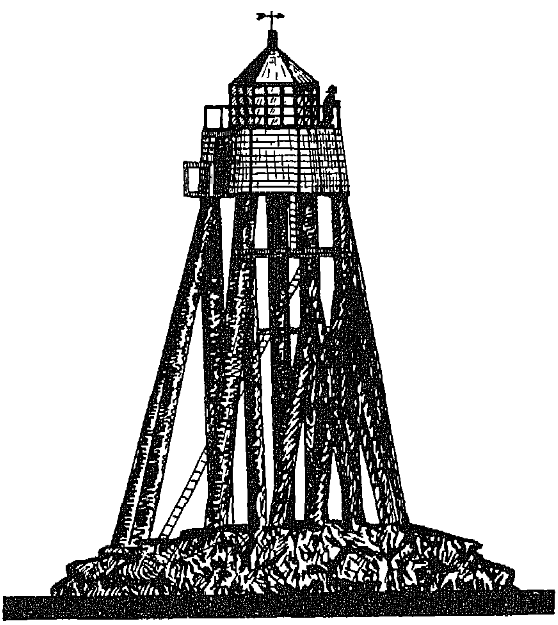
The stone tower, when well founded, can withstand the greatest storm. Smeaton's Eddystone tower of 1759, 68 feet high, was the first stone tower, completely sea-girt, to be inhabited continuously by lightkeepers. It was a remarkable structure. After a scare in 1835, when Trinity House warned shipping that the lightkeepers might be removed without notice, it was reinforced internally in 1838 and 1865; but it was still suspect. In 1882 it had to be replaced by a new tower, designed by Sir James Douglas and built on another rock of larger area. The Smeaton tower, reinforced or not, had at least lasted for over 120 years, which was not a bad record in a struggle against seas which, although not quite as violent as Skerryvore, were bad enough.

The Bell Rock light, only 100 feet high, cost £61,331. The Abbot of Aberbrothwick, mentioned in Southey's famous poem about Sir Ralph the Rover, was content with a simple bell buoy. The rock was

usually under at least 12 feet of water and it took nearly three years before a light could be shown, in February, 1811, at the top of a tower started in July, 1808.

The founding of lights on these tide-swept rocks might seem unnecessary in many cases, particularly when, as at Beachy Head on the south coast of England, there is a 500-foot cliff only a short distance from the light placed at its foot. In good weather a light would be seen from a great distance if it were placed ashore, but in bad weather sea fog would often obscure a cliff-top light but would leave a lower-sited lighthouse at least partially clear. In any case the submerged rocks off-shore present a greater danger than the cliffs themselves.

There were a number of 'private' lighthouses. Trinity House,



(*b*) Smalls light, 1818.

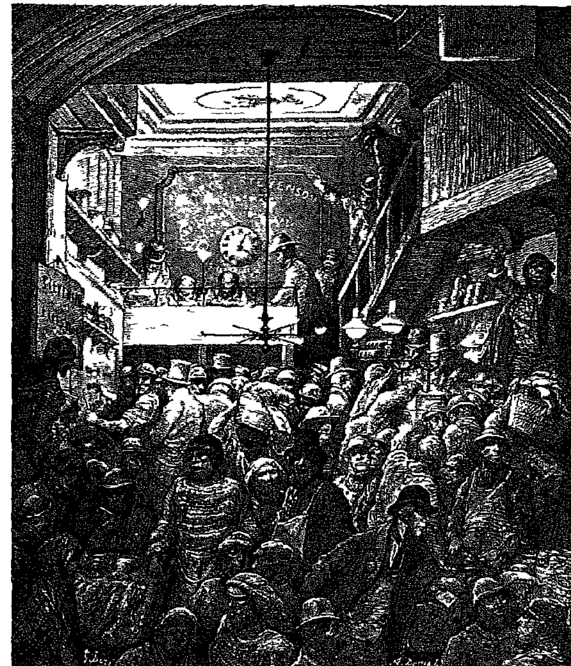
empowered by Charter of Queen Elizabeth I to set up 'beacons, marks and signs for the sea' did not regard their rights to levy tolls on passing ships as particularly their own. This had also been a perquisite granted by various kings to selected tenants. It did not seem proper to interfere with such grants as that to a Lieutenant Smith who, and whose heirs, collected £5,000 a year in dues from the Longships light held at a rental of £100. The Smalls light brought £11,000 a year to John

Phillips who had a 99-year lease at £5 a year from 1778. It cost Trinity House £170,000 to buy up this lease, among others costing in all over a million, in 1834. In England, about this time, ¼*d.* to 1½*d.* per register ton was collected from the ships, other than naval, passing each light. Foreign ships paid double. In Scotland each ship cleared out past their lights paid a composite fee of 2*d.* a ton. The Scottish, or Northern Lighthouse Board, received an income of £15–£20,000. per annum in this way.

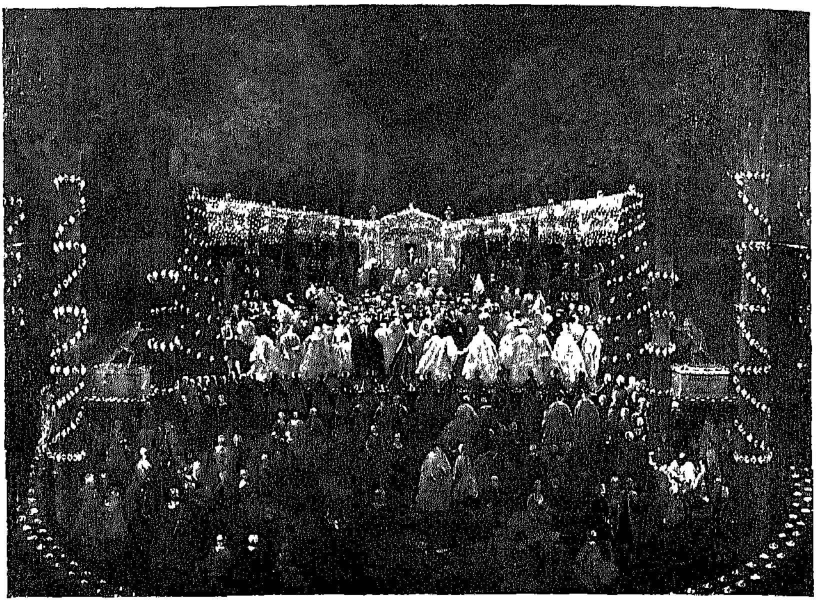
The date of transcendental significance in lighthouse history is surely December 8th, 1858. Sir Humphry Davy, in 1809, had demonstrated the carbon arc light at the Royal Institution in London, but he required a battery of 2,000 cells to provide a fleeting source of power with which to sustain it. The arc light, still fed by primary cells, became a laboratory demonstration and was even used for a scene in the theatre at Paris in 1846. In 1850 a primitive generator of rude coils and horse-shoe permanent magnets was built by Professor Nollet in Belgium. This type of machine was greatly improved by Holmes in England, coupled up to a steam-engine of about 5 horse-power, and used to supply an arc lamp that had been so designed by Holmes that all the adjustments were by miniature pulleys and windlasses that came quite naturally to the old sailors who manned the lights. The first electrically-lit light was at the South Foreland lighthouse in December 1858. The candle-power was over 1,500 and the light source was of manageable size for optical control of the beam. It was only an experimental installation, and it was not until June 6th, 1862, that the apparatus was in service in its final form. In France, M. Reynaud was responsible for the arc-lights at La Heve in the last days of 1863. They were a combination of the Serrin Arc lamp and the Alliance magneto-electric machines of Nollet. The French light was steadier than that of Holmes and many of its features, including the use of alternating currents, were adopted in later British installations.

All this activity did not presage the immediate obsolescence of other forms of lighting. The Drummond light, a high temperature flame of oil vapour and oxygen which was a nine days' wonder around 1835, never got out of the experimental stage and quickly succumbed. The South Foreland lights were electrified in 1872 with 2 lamps of 10,000 and 15,000 candles respectively; but by 1881 there were, in all the world, only 12 electrically-lit lights. Of these 6 were in England, 4 in France, and 1 each in Russia and at Port Said. There were large-scale plans for converting other lighthouses in England, France, U.S.A., Australia and Turkey, but only in selected cases. A contemporary

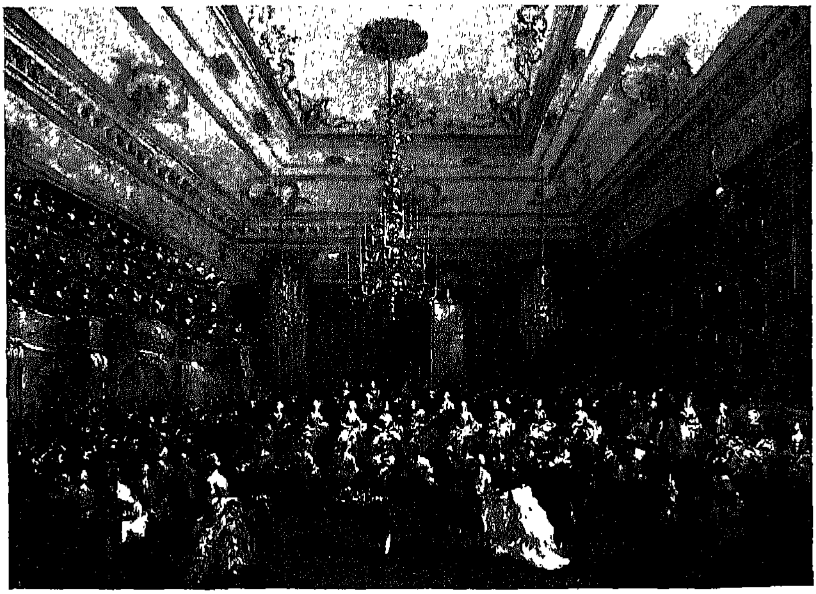
Supper at Vauxhall by George Cruikshank



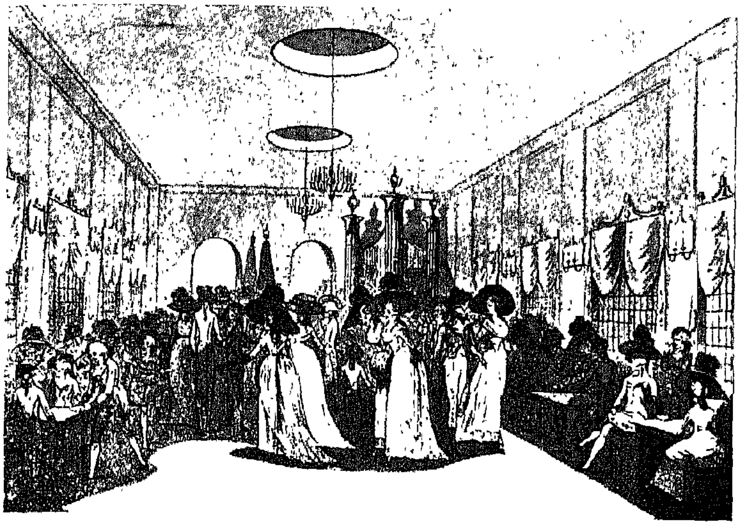
Billingsgate Market, London by Gustav Doré, 1872



Night fête at Herrenhausen, 1741
Property of the Duke of Brunswick

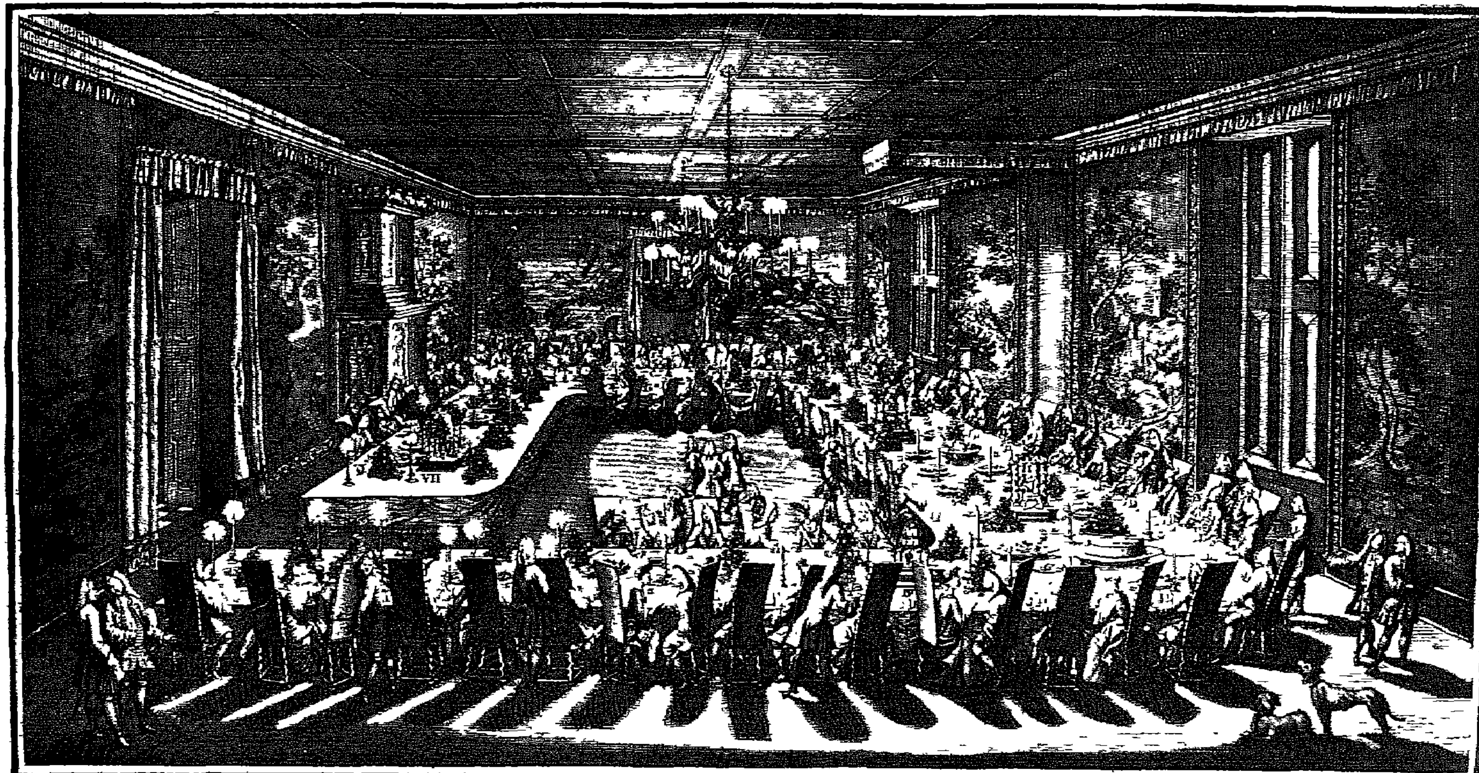


Gala Concert, Venice, 1782 by Francesco Guardi
Property of the Alte Pinathotek, Munich



"Dog and Duck", 1789

"Reverber" street lamp, drawn by Hogarth



Banquet in the palace of the Cardinal of Regensburg, 1717

committee of investigation sponsored in England by Trinity House reported:

(1) that electric light is the most powerful under all conditions of weather; that it possesses the greatest penetration of fog;
(2) that for the ordinary necessities of lighthouse illumination mineral oil is the most suitable illuminant; and that for salient headlands, important landfalls and places where a very powerful light is required electricity offers the greatest advantages.

The first electric filament lamps were of carbon and although lamps of large size were quickly forthcoming the great horseshoe filaments were hardly suitable for lighthouse optics. The possibility of using some development of the filament lamp displayed by Mr. Staite at the Hanover Rooms, London, in 1848 for lighthouse illumination was, according to *The Times* of 2.11.1848, 'partly discussed', but the oil vapour lamp with incandescent mantle burner introduced by Sir T. Matthews in 1902 was the best means of superseding multiple wick oil lamps effectively until, in 1909, the ductile tungsten filament was introduced by Coolidge in U.S.A., and electric lamps could not only become truly competitive but required less rather than more attention than oil. Nowadays with compact coiled filaments and power consumption up to 10,000 watts, the electric lamp is ousting oil and all other forms of illumination by degrees. When a lamp burns out, which is seldom as their average life is several thousand hours, another is automatically put in its place by a safety device that works if the current is interrupted. In important lights there may be a third acetylene source that is automatically lit and brought into focus if the electric supply should fail. Even in the first installations of Holmes a stand-by oil lamp was always kept in readiness.

LIGHTSHIPS AND HARBOUR LIGHTS

Lightships, as distinct from lighthouses, were relatively uncommon. The earliest seems to have been established at the Nore in 1732 and to have consisted of 2 large candle lanterns suspended from the yards of a small sloop. There were about 10 of them around the coasts of England by 1815, mostly kept by Trinity House, but 3 of them maintained by the Admiralty for use during the Napoleonic wars. There were no floating lights outside the British dominions. Lightships have always required a large crew (usually, these days, of 11 or more) and when riding a storm at a cable's end can be most uncomfortable.

They are used in those locations where sunken rocks or sandbanks constitute a danger without providing a foundation practicable for a tower. There are two schools of thought about lightships. Those in U.S.A. are usually of iron and are capable of manœuvring under their own power. Those in Britain have more commonly been of wood, although iron is now used more than it was, and are without engines, so that they have to be towed to and from their location. The wooden ships require less frequent attention than those of iron. The lightship is always specifically designed for its job. In 1953 the most powerful light afloat was at the Ambrose lightship near New York in which, by international co-operation between U.S.A. and Britain a maximum beam power of 5,560,000 international candles has been achieved. A 1,000-watt high efficiency lamp is at the focus of each of 8 mirrors in 4 pairs.

Light buoys are equipped with automatic apparatus, including changers of defective lamps, and may be run off batteries or acetylene. They require attention at regular intervals well within the life of whatever illuminating source is provided but are now of great reliability. In the late 1870s, and for some decades afterwards, oil gas under 10 atmospheres pressure was used by Trinity House for such lights.

Harbour lights are of ancient origin and, until comparatively recent times, were primitive in the extreme. Coal or wood fires could not be permitted on account of the danger to the ships in harbour. A single candle or a primitive oil lamp in copper lantern was therefore the usual source of light. Most lights were quite local affairs maintained more or less casually to assist local seafarers. Portsmouth, Southampton and Bristol, to name but three busy ports, had no official lights as late as 1834. Robert Stevenson,[1] in 1801, recorded of the light upon the pier head at Whitehaven in Cumberland that it 'is from oil, with one reflector, which is ill constructed and in bad condition. These lights are shown only during part of the flood and ebb tide. They are under the management of the harbourmaster, and as the charge of them is given to the pilots who belong to the harbour boats, they are but indifferently attended to'. As the same time the Workington lights nearby were 'from candles suspended in two copper lanterns which by means of a tackle are warped out on a pole fixed outwith the pier heads'. Today, in practically every port of any importance at all the maintenance of adequate lights has become a civic responsibility.

Harbour lights on the Continent, such as those at Naples, Genoa

[1] *English Lighthouse Tours.* Loc cit.

and Corunna, were really to be regarded as sea lights. In England and Scotland a few such lights, such as those at Liverpool, Bristol, the Clyde and the Tay, were kept going all night but many others, as in the Isle of Man, Leith, Aberdeen, Ayr, Whitehaven, etc., were only lit when the depth of water in the harbour was sufficient to enable vessels to enter. They were, in fact, of entirely local significance and were not intended in any way to act as a guide to passing ships at sea. Two such lamps were lit at Calais, from 1750 onwards, two hours before to two hours after full tide.

CHAPTER X

The Materials of Light

AMONG the questions most frequently asked about early lighting are 'What is tallow?' and 'What oil did they use?' In either case the answer is far from simple.

WAX AND TALLOW

Any animal fat, suitably rendered, becomes tallow. The rendering consists of melting down, and straining away the proteinous matter that could go bad. Unfortunately it was not easy to get rid of every last bit of putrescent material, nor always to do the rendering before putrefaction had set in. Thus John Evelyn in *The Smoake of London Dissipated*, petitioned Charles II in 1661 against

'the chandlers and butchers because of those horrid stinks, nidorous and unwholesome smells which proceed from the tallow.'

Shakespeare, in Cymbeline i. 7, refers to impure tallow in the lines:

> 'Base and unlustrous as the smoky light
> That's fed with stinking tallow.'

A great trade grew up in tallow which was wanted for soap-making as well as candles. Mutton tallow, from rams, ewes, bucks and she-goats was greatly favoured as it was both white and hard. Beef tallow, or mixed tallow was used for the cheaper kinds of tallow dip and Gilbert White of Selborne described, in 1789, how 'the careful wife of an industrious Hampshire labourer' could make all her rushlight dips for nothing, as for fat 'she saves the scummings of her bacon pot'. The relative proportions of stearine and oleine in tallow varied not only with the species, age and sex of the animals used, but also with different parts of their carcasses. The degree of solidity also varied, to some extent, with the animals' diet. The commercial value varied

considerably according to the hardness and melting point. Although trade tallow was almost exclusively from the ruminants, local tallows were extracted from a great variety of animals and some vegetables.

The pastoral areas of the world provided the tallow of commerce, and from Russia, South America, North America and Australia huge quantities were exported. It was not until 1861 that Thomas Mort erected the first freezing works at Sydney. Before frozen and, later, chilled meat found a market, millions of cattle were slaughtered in Australia and South America for their hides, hoofs, horns and tallow. The flesh was used as manure or fed to pigs. Russian tallow, which was almost wholly from beef cattle, was bought mainly by candle-makers, but better-class tallows were shared with the soap boilers. The tallow production of the United Kingdom in 1880 was over 100,000 tons and imports were of a like amount. To these figures must be added the production of innumerable housewives saving tallow for home-made dips.

Vegetable tallow came from the Chinese 'tallow tree' (*Stillingia sebifera*) which was introduced into India and the warmer parts of America. The fruits, about half an inch in diameter, contain three seeds richly coated with fat which, after processing, is almost pure stearine melting at 98–111° F. Practically the only use for it in China was for making candles; or rather candle cores for they were most frequently coated with wax to make them stiffer in hot weather. An immense native trade was carried on, Hankow exporting 5,000 tons in 1878. Other vegetable tallows were made from the nuts of the HOPEA, in the East Indies and from the seeds of *Tetranthea laurifola* in other parts of tropical Asia. The disagreeable odour of the latter did not seem to invalidate its use for candles. Similar substances were used in Sierra Leone and Zanzibar. In the remoter regions of the Amazon the Jivora Indians still use cotton-fibre wicks impregnated with rubber. It is to be presumed they countenance the smell for the sake of the light.

In 1823 Chevreul, in France, isolated stearine and published a classic paper on the composition and properties of the fatty acids. A process for separating the solid and liquid constituents of coconut oil by hydraulic pressure followed in 1829 from James Soames. This patent was purchased by two tallow merchants named Wilson and Lancaster who founded the famous 'Prices Patent Candle Company' (originally E. Price & Company, although there was never a Price among the founders) that still operates on the same site at Battersea, London. This firm, in 1835, began to produce stearic acid by the chemical

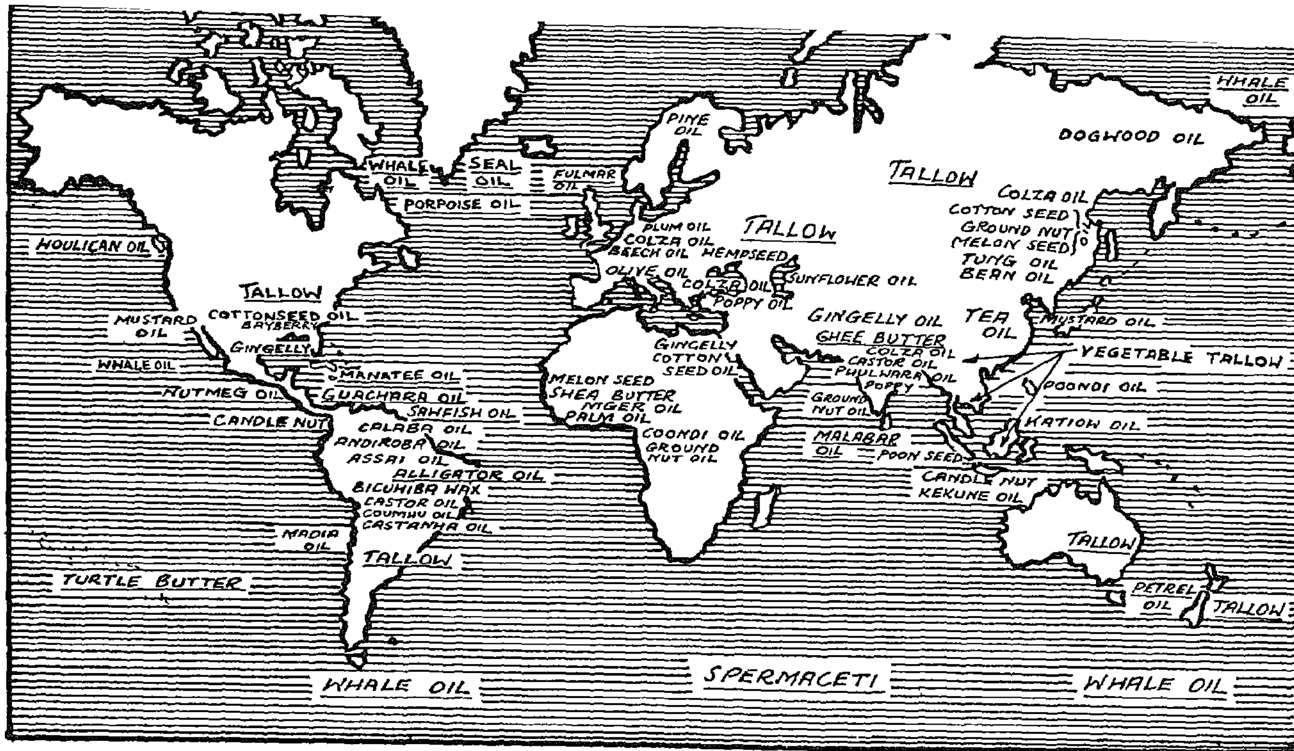


Fig. 56. The Materials of Light, animal and vegetable
(*animal products are underlined*)

treatment of tallow, and five years later, for the marriage of Queen Victoria, they produced pure white, snuffless candles at 1*s.* a lb. containing equal parts of stearic acid from tallow and hard fat from coconut oil. It was of such candles that Thackeray wrote in *The Virginians:*

'Let us comfort ourselves by thinking that Louis Quatorze in all his glory held his revels in the dark, and bless Mr. Price and other Luciferous benefactors of mankind for banishing the abominable mutton of our youth.'

It was in the 1860s that paraffin wax began seriously to usurp the position of these greatly improved tallows for candle-making. Ozokerit, or 'earthwax', found in the region of the Roumanian oil wells, later proved as superior, at a price, to paraffin wax candles as spermaceti proved, at a price, to either beeswax or tallow. Spermaceti or 'head matter' was obtained from the head cavity of the sperm whale which was hunted in the Pacific and Indian oceans. Up to 45 barrels could be obtained from a single whale and this, after boiling and purification became a transparent, smooth inodorous matter melting at 113° F. and burning with a bright flame. The demand was great: £45,000 worth of sperm oil was exported from Tasmania in 1876 and America produced 1,300,000 gallons in 1878. These figures must be interpreted with caution. 'Head matter', for candles, was quite different from sperm oil for lamps. The sperm fishery blossomed towards the end of the 18th century and in 1756 one Sarah Field described herself on a bill-head as a maker of 'the new Spermaceti candles'; but even Shakespeare knew of it, although not for candles. In *King Henry IV,* i. 3, Hotspur says:

'and telling me the sovereign'st thing on earth
Was Spermaceti for an inward bruise.'

The price of candles of various materials may provide as good an indication as any of their virtues. In 1847 sperm candles were 1*s.* 11*d.* per pound; the cheapest tallow were 6*d.* In between we have Price's pure white, snuffless candles at 1*s.* and beeswax candles a little dearer. In Gilbert White's day (1784) eleven rushlights, each burning for at least half an hour, could be bought for a farthing. The 'farthing candle' was a term synonymous with cheapness. Thus Charles Lamb (1775–1834):

'Some cry up Haydn, Some Mozart
Just as the whim bites. For my part

I do not care a farthing candle
For either of them, nor for Handel.'

Beeswax, for candle-making, was certainly known to the Romans who cleaned it with sea-water and bleached it in the sun. King Alfred's (9th century) 'time keeping candles' were simply beeswax candles about $\frac{2}{5}$ of an ounce in weight, each of which burned for about four hours. In earlier days, for church candles, one or more brothers always had as their especial charge the apiary of a monastery. This was not exclusively on account of wax for the candles, as drinks of the mead type were made from honey, which was also the principal means of sweetening.

The superiority of beeswax was well shown by the words of John Colet in the Foundation Statutes of St. Paul's School, London, in 1512:

'In no tyme in the yere shall they use talought candill in no wyse, but only wax candill at the cost of theyre friends.'

That cost would be considerable. Urbain Grandier, sentenced to be burnt at the stake in Loudun in France in 1634, had first to ask pardon with a rope round his neck and a wax taper of 2 livres in his hand. In the accounts of the trial the cost of the candle is given as 40 sols, which, using Sir Isaac Newton's conversion tables prepared for the Royal Mint in 1719, makes the price equivalent to 1*s.* 5*d.* per pound. At the Court of Louis XIV (1643–1715) no candle was ever re-lighted and the unburnt ends became a valuable source of income for the ladies-in-waiting who claimed them as a perquisite.

The charter granted by Edward III to the London Wax Chandlers in 1358 contained ordinances against adulteration upon pain of increasingly severe penalties for each offence. For the second offence there was the pillory in addition to the destruction of stock; while a third offence meant expulsion from the City. In particular the chandlers were forbidden to add to the beeswax:

'any fat, code (cobbler's wax), rosin or other manner of refuse, nor shall they use old wax and worse within, and new wax without.'

There was, however, a proviso that for any 'reputable man' they might make candles 'of old and new wax mixed together for his own use'. Old wax was commonly used again. The Churchwardens Accounts of Eltham, Kent[1] for 1555, include 20 pence for working

[1] *Archaeologia Cantiana,* Vol. 47, 1935.

old wax against 88 pence for new. Four years later the accounts itemize:

New wax, 9 lbs.	9 shillings
Cost of working	9 pence
Cost of working 11 lbs. of old wax	11 pence
Nails for the wax chandler to hang the taper upon	1 penny

In addition eightpence was paid to the chandler's assistant, ninepence for drinks for both of them and other helpers, and sevenpence for a quart of oil. Between the two dates they seem to have gone over to oil heating, for in 1555 the chandler consumed eight pennyworth of firewood. The rolls of the Clerk of Middlesex Sessions in 1581 refer to fines of 12*d.* on four chandlers charging $2\frac{3}{4}$*d.* instead of $2\frac{1}{4}$*d.* per lb. for tallow candles.

In 1710 the tax on beeswax candles in Britain was as high as 4*d.* per pound while tallow was taxed at $\frac{1}{2}$*d.* Small rushlights for home consumption only once dipped 'through grease or kitchin-stuff, and not at all through tallow, melted or refined' could be made duty-free.

Beeswax is from one point of view a vegetable product. The fruit from a tree of the species *Litsoea*, found in the Punjab, Himalaya, Java and other areas, was said to give enough vegetable wax to make 500 candles per tree. In Brazil candles were made from the fruits of a tree supplying 'bicuhiba wax'. Bayberry candles were made in U.S.A. Walter Hough, in Bulletin 141 of the Smithsonian Institution, Washington, published in 1928, describes the use of bayberry wax by the economical housewives of New England:

'It is said to have been discovered by a New England surgeon who made it into candles and introduced it into medicine. The Indians made no use of the wax, as stated by Pere Lafiteau in his work of 1724. In Middlesex, West side of the Connecticut River, near Haddam, is Candleberry Hill. There is tradition of the use of the wax from berries here to make candles during the Revolution. The method of extracting the wax was to fill a kettle half full of water, put the bayberries in and boil them. The heated mass was then put in a bag over a kettle of water and strained. As the water cooled a film of wax consolidated on the surface. This was the desired wax. The wax was not only used in making candles but was mixed with tallow to harden the candles made for summer use.'

An interesting aside is that it was this bayberry wax that was used

for the cylinders of the early graphophones, forerunners of the modern gramophone record.

It is difficult to determine the extent to which candles were used in different places at different times. As far as Great Britain is concerned a hint of the scale of things is to be found in the account in the *Universal Magazine* of 1784 of the budget proposals of Mr. Pitt:

'On these (candles) he meant to impose only an additional half penny per pound. In poor families he believed not more than 10 lb. of candles were consumed in the year; this, therefore, would be an addition of only 5*d.* per annum, and yet would produce £100,000.'

Simple arithmetic gives the total weight of candles subject to tax at 20,000 tons. This spread over $7\frac{1}{2}$ million inhabitants gives an average of 6–7 lb. per head or about 30 lb. per family. Taking into account the great number of home-made rushlights and tallow dips these figures are formidable. The rich must have bought candles by the hundredweight, even allowing for the quantities consumed in the lighting of factories and offices. Taxes on candles continued to be levied until an Act of Repeal in 1831.

To compare one type of candle with another the following figures, of about 1880, gave the relative weights of various materials estimated to give a light equal to that from 1,000 grains of spermaceti:

Ozokerit	754
Paraffin Wax	708-891
Beeswax	1150
Stearine	1200
Tallow[1]	1300 or more

The oil lamp is usually held to be something quite different from a candle, but this is not so. The top of a candle might be regarded as a small oil lamp, the oil being replenished by melting of tallow or wax as the candle burned down. The matching of the wick to the candle was a matter of considerable importance as, if the wick was too small, the melted matter was not consumed and ran over the sides; if the wick was too big there was not enough melted matter to feed it and it smoked. These factors have been known for a long time; thus, in the ordinances applying to wax chandlers in 1358 there is the following warnings:

'and that they shall not make their wykes, which they put into such

[1] Depending on the purity and consistency

manner of work, of excessive weight, so as to be selling wyke for wax, to the damage, and in deceit, of the common people; but let wyke be in accordance with the quantity of wax, as it reasonably ought to be.'

Tallow candles were even more difficult to manage as an untended wick bent towards the molten material to cause 'guttering' by which most of the tallow ran to waste instead of being burned for light.

OIL (ANIMAL AND VEGETABLE)

In the candle the 'oil' is solid. In the oil lamp it is liquid and a container is required to hold it. In principle that is the only difference. There is an intermediate stage, the grease lamp, which is probably the oldest illuminant of all apart from the fire and the firebrand. The candle derived from the grease lamp, but not until, as far as is at present known, the 5th century B.C. at the earliest, when oil lamps had certainly been in use for at least 2,000 years and grease lamps for much more than 12,000 years. The Lascaux cave paintings were illuminated by at least 100 lamps, probably grease lamps, that have been discovered in that later Palæolithic period temple of 15,000 years ago. In the Louvre, Paris, there are bowl-shaped earthenware lamps retrieved from the inviolate tomb of Deir el Medineh of the New Kingdom of Egypt. These, perhaps 2,500 years old, still contain their grease and linen wicks. It is so easy to imagine the transition from the odd twig or fibre burning in the grease falling from a prehistoric roast to a conscious repetition of the phenomenon in a lamp, that the grease lamp seems practically inevitable. For the oil lamp, however, a process of manufacture is required as an intermediate stage. It represents, therefore, a more conscious step in the march of civilization.

The grease lamp, nevertheless, could be preferable to the lamp fed with crude fish oils, the smell from which could be most unpleasant. In an Act putting duties on candles in Britain in 1710 it was enacted that:

'during the continuation of the Duties upon candles no person whatsoever shall use in the inside of his dwelling house any lamp wherein any oil or fat (other than oil made of fish within Great Britain) shall be burnt, under penalty of forty shillings for every offending light.'

Fish oil gave light to those too poor to afford the less offensive

tallow for either lamps or candles. 'The smell of the lamp' was remarked upon by Herrick in his *Farewell to Sack*. All oils, to some degree, left a pervasive smell on the fingers of those who had to manage lamps. They were also messy. For such reasons servants and slaves were called upon by their masters to give whatever attention might be required. The rich man would rarely, if ever, touch the lamp himself. The cleaning and polishing of lamps (and candlesticks) in a large house was one of the major tasks in the servants hall.

Among the earliest oil lamps known are those from the Royal Tombs at Ur of about 2,600 B.C. There is some ground for the belief that the Sumerian word for oil indicated that the seepages from petroleum deposits formed the source. On the other hand the Sumerians clad themselves in sheepskins and feasted on sheep and goats, so that it is not at all unlikely that they had animal fat to spare for their lamps. On those lamps that have survived there are frequently prophylactic markings for propitiation of the Gods. From very early times a lamp lit at a sacred flame acquired particular significance. Natural flames such as those from petroleum gases were revered. It is therefore not unlikely, although purely conjectural, that lamps in Sumeria were divided into those with religious significance and those used domestically. There is at present no conclusive evidence.

In Exodus, Leviticus and Numbers there is written evidence of the use of specially pure olive oil for the lamps before the Ark of the Covenant:

'And thou shalt command the Children of Israel that they bring unto thee pure olive oil beaten for the light to cause a lamp to burn continually.' Exodus 28, v. 27.

In Numbers, 4. 16, there is the allocation of duties:

'And the charge of Eleazar, the son of Aaron the priest, shall be the oil for the light, and the sweet incense, and the continual meal offering, and the anointing oil.'

Olive oil has been used for lighting as well as food up to quite recent times. The 'virgin oil' of great purity was skimmed, in very small quantities, from the top of the pulp of crushed olives. The oil from the first pressing was also of fine quality, but afterwards boiling water was added to the pulp, the mass stirred up, the further oil being extracted by pressure. Oil from the second pressing was good, but became rancid after a time. More boiling water and pressing gave an inferior oil commonly used for illumination and known

as 'Pyrene oil'. In France, after the third pressing the oil-bearing water was led to huge underground cisterns from which, after a time, a very inferior oil known as 'oil of the infernal regions' was skimmed. This oil was used locally for lighting, but it was probably the 'virgin oil' that was specified for the light before the Ark of the Covenant.

The Jewish festival of Chanucah, about Christmas-time, celebrates the entrance of the victorious Maccabees into Jerusalem. They found the sacred light in the Temple extinguished and only enough oil for a very short time. The belief is that this supply lasted miraculously for eight days; but non-believers might remark on the ease with which a light could be maintained by adulterating the oil, even with fat. Fresh supplies could be obtained from any store of olives, whatever the time of year, for although the oil does not keep so well if the olives have started to ferment it was nevertheless common practice to keep heaps of olives and press them whenever convenient.

Olive oil is one of the more obvious examples of the competition between usage for lighting and usage for food. If food was short, lighting suffered. Normally speaking oil for the lights had to be surplus oil and therefore some of the most primitive peoples—such as the Vancouver Island Indians—might have abundant light from the local bounty of nature while more civilized communities had little. In some areas oil was also the fuel for cooking while in some hot climates the insect-repelling qualities of certain oils made them more popular for anointing the body regardless of their unpleasant smell. Sometimes abundant oil for lighting and cooking might be a by-product of the local economy. Thus, in cotton-growing areas three pounds of seed were produced for each pound of ginned cotton. Only half this amount was required as seed and the rest gave abundant supplies of oil and a residue of oil-cake that was valuable as a cattle food. In other areas fish-oil was available in almost unlimited quantities. The Russians evacuated with the British troops after the Netherlands campaign of 1799 not only scraped all the tallow out of the naval lanterns and ate it, but they also astonised the people of Yarmouth, where they landed, by drinking the oil out of the street lamps.

An interesting further sidelight on the edibility of many lighting media is given by choice of stearine candles instead of paraffin wax for polar exploration. The Scott Antarctic Expedition of 1911 took a ton of stearine candles, and it is recorded that they did actually eat them on occasion. Lighthouses, in the 18th century, commonly showed only one or more tallow candles. John Smeaton, in his account of the

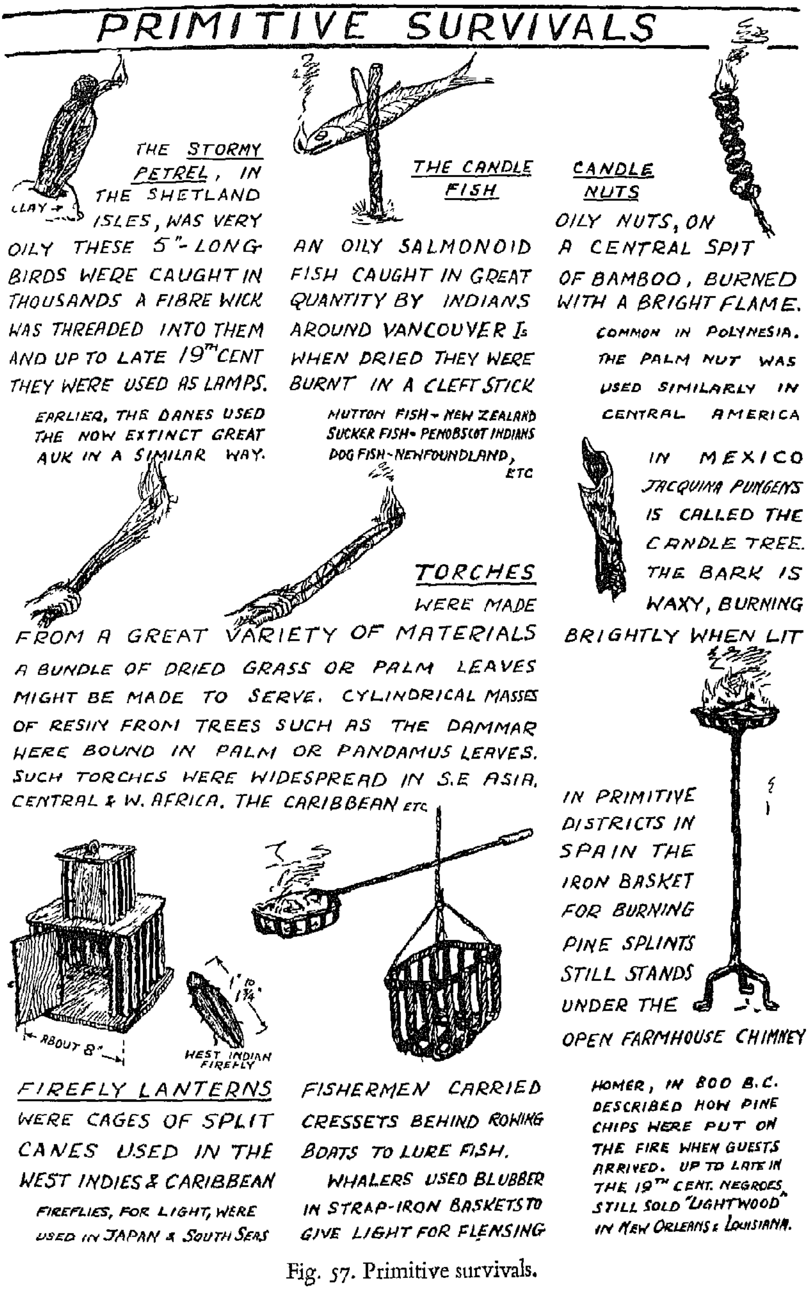


Fig. 57. Primitive survivals.

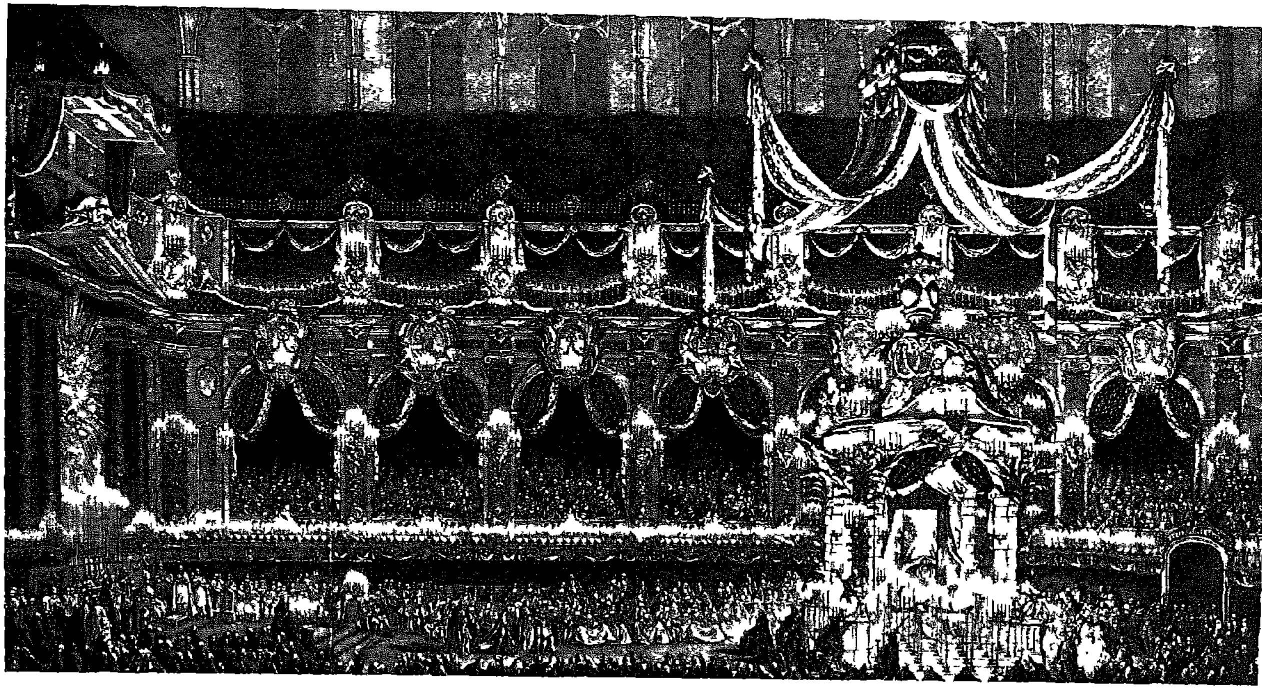
building of the 'Edystone' lighthouse published in 1793, recorded of his visit to Plymouth nearly forty years earlier that 'I found it a matter of complaint through the country—that the light keepers had at various times been reduced to the necessity of eating the candles'. His inquiries showed that they had been 'embezzling stores and bartering for strong liquors, then alledging that they grew bad and that they were obliged to throw them into the sea; so that the eating of the candles was an early complaint'. Plumbers preferred tallow to wax candles for another reason; the tallow could be used as a perfectly good flux in the wiping of a lead joint.

The oils used for lighting were so many and varied that a catalogue would make very dull reading. Before mineral oil became popular in the 1860s the best esteemed oils in an order of merit taking account of density, coefficient of expansion, congealing and liquefying temperatures and illuminating power were given as colza oil, coconut oil, ground-nut oil, olive oil, sperm oil and whale oil.

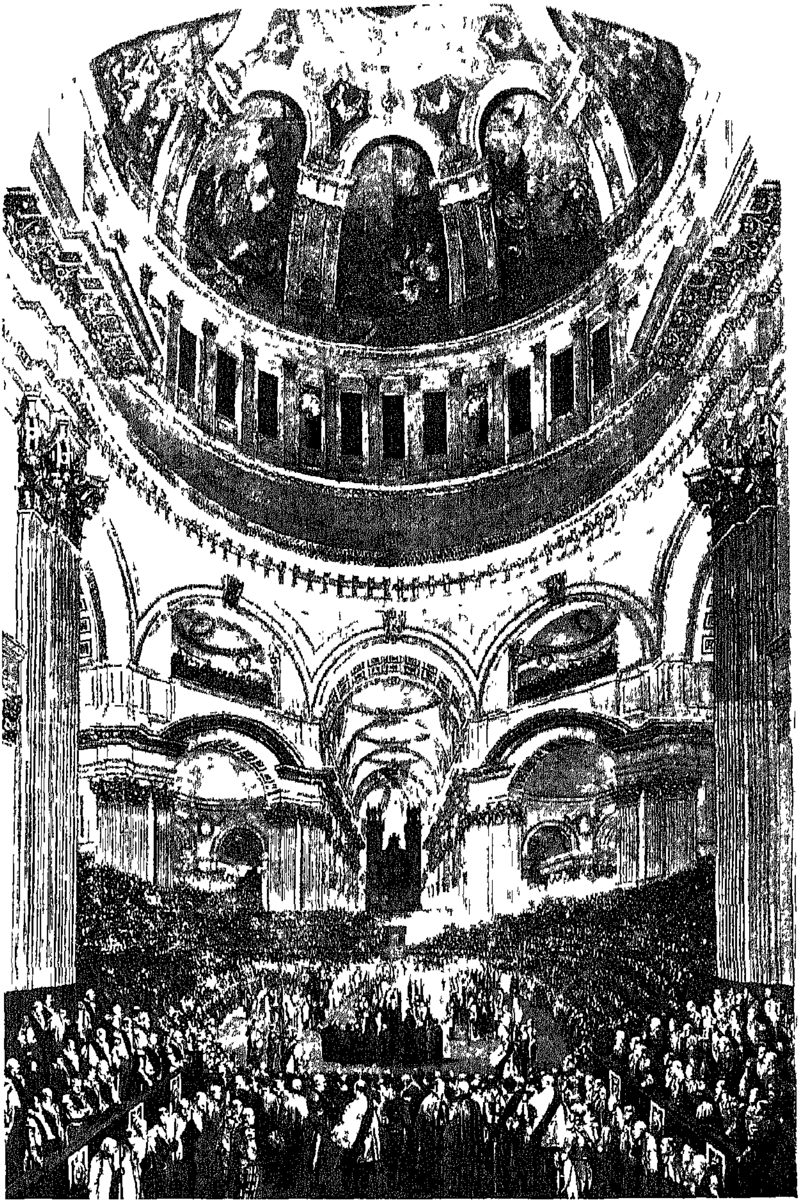
Colza oil and rape oil are identical, while 'Carcel oil' usually meant the same thing. The basis was the seeds of several types of *Brassica*, or kale. The crop was extensively cultivated on the continent of Europe, in India and China. France had over 400,000 acres under this crop in 1873 and India shipped 150,000 tons of seed in 1877, mainly to Danzig, where crushed 'Gujaret rape' was a well-known product. The Ichang district of China produced large quantities of colza oil. In time the oil aged and became very smelly, burning with a most unpleasant smoke.

In wine-growing districts an excellent oil, emitting a bright light quite free from smoke, was obtained from grape stones. About a pound of oil could be got from the refuse remaining from the manufacture of 6–10 gallons of wine. There were many such seed oils, among them Gingelly oil produced in large quantities from the seeds of the Sesame bush. This was originally a product of India but the plants were propagated in nearly all tropical and sub-tropical countries, 50,000 tons of the seed were exported from India in 1879 and there was considerable trade in the oil. Most of it went for soap-making and as an edible oil, but in India particularly it was extensively used for illumination. Tea seed oil was another illuminant common in India In West Africa, China and parts of India oil was extracted from melon and pumpkin seeds; perhaps, as Edward Lear said in one of his nonsense rhymes:

> 'On the coast of Coromandel
> Where the early pumpkins blow. . . .'



Funeral of King Philippe, Notre Dame, Paris, 1746



Funeral of the Duke of Wellington in St. Paul's Cathedral, in 1852. The blacked-out cathedral was lit by thousands of gas jets

Illustrated London News

Coconut oil was used mainly for soap-making, particularly as coconut-oil soaps were relatively soluble in salt water. It would be wrong to ascribe the great trade in copra from the South Sea Islands, Ceylon, the Coromandel coast and Malabar to the needs of illumination, even though the oil burned excellently in lamps. In tropical climates it was a white oily liquid almost as limpid as water, but it solidified at 61–64½° F. and was usually solid or cloudy in Europe. Palm oil, mainly from West Africa, served much the same purposes and was in many ways similar; 3¼ million gallons were exported from Lagos in 1877 and much of this went to candle factories. It was said that the importation of palm oil took the profit out of the African slave trade 'as it paid the kings (and chiefs) better to employ their people in oil collecting than to sell them as slaves'. The relatively small depredations of the European slave raiders continued as before, but they were denied the collusion of the natives' own masters. To that extent their odious business became more difficult. Some of the traders may have degenerated into raiders when the chiefs began to prefer to keep their 'black ivory' in servitude at home, but raiding was never as extensive as 'trading'. In the same area of Africa mote grease, from the fatty nuts of the *Touloucoona* tree was extensively used for lighting.

Ground-nut oil came mainly from India, Java, China and West Africa. It was more favoured for soap-making than as an illuminant in Europe, but locally was used for lighting, cooking, burning and food. Kekune oil, from Honolulu and the Pacific Islands was obtained from the very oily 'candle nut', so called because the natives would simply thread the nuts on a stiff fibre to provide themselves with quite satisfactory candles.

Sperm oil and whale oil, together with a shark oil from the basking shark, were produced in great quantities. The oils were somewhat inferior to the best seed oil for lighting, but the first reflector oil lamps installed by Trinity House as lights at the river Mersey in 1763 used flat wicks burning whaleoil.

It was towards the end of the 18th century that whale fishery began to develop rapidly to fill the demands for oil and spermaceti. The hazards had been known long before. Thus Sir William Davenant (1606–1668) in an allegorical poem:

> 'For angling rod he took a sturdy oake
> For line, a cable that in storm ne'er broke
> His hooke was such as heads the end of pole

To pluck down house ere fire consumes it whole
The hooke was baited with a dragons tale
And then on rock he stood to bob for whale.'

and Swift, in *Gulliver's Travels*, recorded that:

'Seamen have a custom, when they meet a whale, to fling him an empty tub by way of amusement, to divert him from laying violent hands upon ship.'

In these days of colossal 20,000-ton factory ships, powerful hunting vessels and electric harpoons, it is as well to remember that the whole of the American whaling fleet of 178 vessels in the 1870s had a total burden of less than 40,000 tons. With this fleet over a million gallons of whale oil was produced annually, mainly from the Bering Straits, South Pacific and off the coast of California.

Other animal oils used for lighting, included Houlican oil from a small salmonoid fish that ascended the rivers of Vancouver Island and British Columbia in millions during April and May to spawn. These fish were so oily that the Vancouver Indians dried them, stuck them in a cleft stick and burned them as they were. The almost human-looking Manatee was hunted in the creeks and inlets of Central and South Africa, West Indies, Mexico, Brazil and Guiana; 5–25 gallons of excellent oil were got from each animal. Alligator tails, in Central Brazil, provided 12 or more gallons of oil each; and seal oil was, and to a lesser extent still is, of great importance to the Greenland Eskimo.

A little different from those oils was the ghee butter made from the milk of the Indian Buffalo and used extensively for lamps as well as cooking. As recently as 1948 H. W. Tilman described how, during his exploration of the Langtang Himal on the borders of Nepal and Tibet, he came across a village high in the mountains that depended on a trade in skins of butter to maintain the myriad lights in the valleys below. In India this butter is an expensive food, but transport is the problem. A vegetable butter, known as Illipi butter, was similarly used in Malabar and along the Coromandel coast.

Oily birds have also been used for lighting. The Shetland islanders, up to quite recent times, caught and dried stormy petrels into the bodies of which they threaded a wick through the beak. The bird, when wanted for use, was stuck by the feet in a lump of clay and burnt as a lamp. The stomachs of these birds are so full of oil that in Tasmania and new Zealand similar species were caught, held upside down and squeezed alive until they ejected oil, and then released apparently little the worse. Centuries ago the Danes were said to use the now

extinct Great Auk as a lamp by inserting a moss wick in the belly of a dead bird. In Venezuela the Indians caught immense numbers of young, fat birds in dark underground caverns where the nocturnal Guachero or 'oil bird' bred. They were hunted about midsummer with torches and long poles, the bodies being rendered for oil over fires built at the cave-mouths.

Quite apart from the many local demands there was a huge trade in oils and fats for lighting and soap-making. In 1838 Britain alone imported £1,137,685 worth of palm, olive, train, sperm and blubber oils, while over 1¼ million hundredweights of tallow were also consumed. About this time there was a trickle of mineral oil distilled in closed retorts from Scottish or Irish bog peats and selling profitably at 2*s.* per gallon. Only 300–400 gallons of oil could usually be got from 100 tons of peat, but from the bituminous peat of the Hebrides this figure went up to 1,000 gallons. Later paraffin was obtained from Scottish shales, and in 1857 Burma oil was shipped to London where, in superheated steam stills it gave paraffin wax for candles, burning oil and lubricating oil. In 1859 10,000 gallons of lamp oil was actually shipped from London to New York, but in the same year the Pensylvania wells were opened by Colonel Drake and America began literally to flood the markets of the world with cheap mineral oils.

MINERAL OILS

Petroleum from surface seepages was known to the Sumerians and the burning gulf at Ecbatana was of mineral origin. Herodotus (450 B.C.) described a well not far from Susa. The flames from natural gas sources were often regarded as of particular religious significance and still are. Maurice Herzog, in his book *Annapurna* (Jonathan Cape, 1952), describes the sacred flames of Muktinath, Nepal, where Buddha lived as a youth some thousands of years ago:

> 'A little way to the South they visited another Temple guarded by a dozen maidens dressed in coloured robes. A stone was lifted up and Ichac and Oudot were shown two narrow apertures. Along them came the sound of flowing water and in them flickered the flame of a natural gas which burned perpetually. The vestals sang and danced and the Sahibs offered their mites.'

Natural gas is pumped through vast lengths of pipe-line in North America and such cities as Medicine Hat in Alberta get all their heat and power from the gas sources over which they are built.

In 1629 d'Allien described how the American Indians collected the grease from natural seepages to use medicinally on sores; and Marco Polo, in the 13th century, described the use of mineral oil to cure mange in camels. John Milton (1608–1674) even knew of it as a possibility for lighting. In his description of Pandemonium in *Paradise Lost* he related how:

> 'From the arched roof,
> Pendant by subtle magic, many a row
> Of starry lamps and blazing cressets, fed
> With naphtha and asphaltum, yielded light
> As from a sky.'

Licetus, in 1621, described how burning bitumen or naphtha gave a light that might be spread, but not extinguished by water (*De Lucernis*, Book 2, ch. 6), and in 1830 Reichenbach described how a wick impregnated with paraffin wax would burn 'like a fine wax candle and without smell'. Paraffin wax, obtained from seepages or from shale, was at that time a dark brown, unattractive-looking substance. It burned brightly, however, and was used in numbers of coal mines in Scotland and northern England. The colour could be improved by dissolving the wax in naphtha but the extra processes of making the colour better upset the economic balance so that stearine, up to the decade 1870–80, hardly felt the competition. In 1871 Hodges patented an economical process of making white paraffin wax by sweating and from then on paraffin wax began rapidly to capture the market.

In Roumania and Moldavia crude petroleum was used by the peasants as wagon grease, and medicinally long before, in the early 1850s, it was distilled to produce a lighting oil. As in Sumeria and 18th-century America, this crude 'rock oil' had probably also been used as fuel for lamps. Roumania and Burma were both in large-scale production before Pennsylvania, but the wells were nothing like the 'gushers' with which we associate boring for oil today. They were simply deep holes in the ground, about a yard square and 60 to 350 feet deep. The oil was lifted out in buckets, as with the traditional water well, and the daily output seldom exceeded 140 gallons. There were 4,000 to 5,000 such wells in Galicia in 1880.

The American Indians collected rock oil by laying a blanket on the surface of a well and then squeezing it out. There is an account in *Silliman's Journal* of 1826 of wells in the Little Muskingum region, Ohio, from which the oil was beginning to be in demand for lighting workshops and manufacturies where 'it affords a clear, brisk light . . .

and will be a valuable article for lighting the street lamps'. Nevertheless little came of this discovery, possibly because the crude oil burned with an objectionable smell; and there were 60 coal oil refineries, some of them quite large, in U.S.A. between 1852 and 1859. Paraffin or kerosene of good quality is readily obtained by distillation of good gas coal at red heat. About 1860 two Americans, Weston Howard of New Bedford and Samuel Kier of Pittsburg devised processes for refining rock oil. The former used a mixture of alkalis in water as a final reagent and sold thousands of barrels of refined oil at 75 cents a gallon (2 dollars in California to which it was sent via Panama and by mule transport). The latter was responsible for the great refinery at Titusville, Penn., from which a large-scale industry developed. The first wells in Pennsylvania were only 70–150 feet deep; but it was not long before deep drilling enabled what seemed prodigious volumes of oil to be drawn from these and other oilfields.

Cheap petroleum supplies gave both cheap oil for lamps and cheap wax for candles, and both were of first-class quality for their purpose. At first there were no internal combustion engines to raise the demand to unheard-of levels but even so 350 million gallons of petroleum oils were being shipped out of America by 1879. A list of the products of distillation at that time, and the various uses to which they were put, makes interesting reading. In addition to the following there was also a demand for the residual product, vaseline.

Product	Maximum Specific Gravity	%	Application	Price per Gallon
Cymogene	0·603	–	Artificial freezing	6*s.*
Rhigolene	0·629	–	Anaesthetic	4*s.*
Gasolene	0·673	1½	Air-gas lamps	9*d.*–1*s.* 6*d.*
Naphtha	0·723	10	–	2*d.*–4*d.*
Benzene	0·744	4	Paints and Varnishes	6*d.*–8*d.*
Kerosene	0·838	55	Lamp oil	10*d.*–1*s.*
Paraffin oil	0·906	19½	Separated into paraffin wax and a lubricating oil	7*d.*–9*d.*

Naphtha was a difficulty. It could be used safely for very little, but it was an inevitable product of distillation. There was a great temptation to add it to lamp oil; 5 per cent addition of naphtha

produced a lowering of the flash point from 113° F. to 83°F. and 20 per cent addition lowered it to 50° F. at which it was totally unsafe for illuminating purposes. In America, and to a lesser extent in Britain, there had already been experience of such dangers. Between 1830 and 1850 camphine, a volatile mixture of turpentine and alcohol, was used in lamps, but so many were the explosions and so disastrous the fires resulting from the use of a mixture of very low flash point that it went right out of favour.

Kerosene was a stable oil that did not deteriorate with time, which burned brightly without smoke, and which was easy to lead up the wick without such assistance as the little clockwork pumps or compressed spring pistons that were required for colza. It was therefore extremely popular, quite apart from the fact that on figures got out by Trinity House, it was only 87 per cent as costly as colza oil for equivalent light.

In reading old accounts it is necessary to take care not to attribute modern meanings to the words used for the various fractions of distillation. Thus in 1882, Mr. Field in his Cantor Lectures to the Royal Society of Arts in London related that petrol was perfectly safe for lamps and would extinguish a burning match, whereas benzoline was very dangerous. To John Milton naphtha was quite safe. Kerosene, in Britain today, would be called paraffin. Naphtha flares were often called petrol flares right up to the 1920s. The fuel described as petrol in Britain is called gasoline in U.S.A. and Spain, and benzine in France, Holland, Germany, Italy, Sweden and Denmark.

It must be appreciated that when kerosene was first introduced in quantity about 1860 there was little serious competition from other illuminants. The electric arc was known but was hardly out of the laboratory stage even though the North Foreland light had been lit electrically two years before. The electric filament lamp was still a couple of decades away. In the year of the introduction of the Sugg burner, William Ewart Gladstone said in the House of Commons: 'Decision by majorities is as much an expedient as lighting by gas.' The Welsbach or Auer mantle came into prominence only in the 1890s.

Kerosene had one great advantage over gas, and later over electricity as well. In sparsely populated localities the cost of distribution often made a gas supply prohibitive and it is only recently that extensive deliveries of butane gas in cylinders has to some extent broken the hold of kerosene in the country districts. The popular success of kero-

sene may be gauged from the fact that by 1880 there had been 1,600 patent applications for improvements in kerosene lamps. Most of them were useless or transitory in significance, but the figure speaks for itself.

ACCESSORIES

The material requirements of light spread beyond the actual burning materials. Thus, in 1692 the tallow chandlers humbly petitioned the Lord Mayor, aldermen and councillors of the City of London against the lighting of some of the streets with oil lamps. They pointed out not only the threat to their own trade, but also

'to other trades as the horners in the making of leaves for lanthorns for burning candles in, tinmen and spinners of cotton whereof the twentieth part is not, nor cannot be used in lamps which is, and must be, in candles.'

The making of lamps and candlesticks involved a multiplicity of trades. There were not only tinmen but turners in brass and wood, gilders, enamellers, silversmiths, brass founders, potters, glass-blowers and smiths. Power-driven machine tools became common only between 1800 and 1830, so that the brass turners, for instance, scratched at their material on lathes driven by a youth turning a large wheel. No wonder that Hotspur in *I King Henry IV*, ii, 1, is made to say:

'I had rather hear
A brass candlestick turn'd,
Or a dry wheel grate in the axle tree.'

Lamp-making itself must have been an industry of some significance in Athens as fragments of 10,000 pottery lamps of 4th–6th centuries B.C. have already been unearthed. Roman pottery lamps are very easily come by, as they mass-produced them on a vast scale both at home and throughout their empire. Bronze lamps were also made in quantity. Glass lamps seem to have originated in the Middle East, possibly 1,500 years ago. In Europe the demands on the glass-blower were more for chimneys, for the past 200 years or so, and for crystal chandeliers. For lamps spikes, forceps and wick-trimmers were required; for candles snuffers and extinguishers; and also moulds for the candle-maker.

To the wick-makers twisting or spinning the fibres and later the cotton wicks for lamps and candles must be added the rural workers

gathering the materials for rushlights. At the proper time of the year, in high summer and early autumn, they cut, steeped, stripped and dried the rushes. A thin strip of peel was left on the pith to hold it together, a device known to the Romans. This gave the despised rushlight an advantage over the tallow candle. The clumsy rush wick bent over into the flame where, if it was not wholly consumed, it just dropped off. It might make a mess on floor or table, but it required no more and probably less attention than the tallow candle.

It is not known whether any particular significance can be ascribed to an odd scrap of information from a book of statistics for the year 1880:

> 'There is abundant evidence that the antiquated rushlight is still an article of domestic use. Messrs. Haynes supply between three and four tons annually, *principally to the University towns.*'

To all these materials must be added the tow or rags which were coated with resin or pitch to make the 'links' for the link boys. Native torches in many parts of the world were simply made up of resinous matter, perhaps tied up in a palm leaf.

Finally, as one of the most unexpected materials of light, there is the firefly. In the West Indies they were caught and put in a wooden cage, or even attached to the big toes of a traveller with a spot of gum so that he might see any snakes in the path at night. Thomas Moore (1780–1882) has a verse:

> 'and she's gone to the Lake of the Dismal Swamp,
> Where, all night long, by a firefly lamp,
> She paddles her white canoe.'

CHAPTER XI

Getting a Light

It is probable that fire was first obtained mechanically by sparks from flint and pyrites falling on tinder rather than from the heat generated by friction between a piece of hard wood and a piece of soft wood, which implies a rather more advanced stage of tool manipulation. The tinder, in the latter case, is automatically produced in the form of a fine wood-powder generated in the process. The tinder in the former case has to be found, the favourite medium of primitive peoples being dry plant down, dry grass, dry 'touch wood' or some similar easily ignited material. In later times charred rag made admirable tinder but in damp climates such as that of Britain it had to be re-heated every three days or so as otherwise it became virtually useless.

One of the minor international trades of a couple of hundred years ago was in 'German tinder', or Amadou. This was a prepared tinder made by boiling, drying, beating, impregnating with saltpetre and again drying the fungoid growths found on oak and beech trees in the German forests, which Linnaeus classified as *Boletus igniarius*. 'The druggists sell this match wholesale in France,' says *Rees' Cyclopoedia* of 1819, 'and several hawkers retail it.' Amadou did not deteriorate to the same extent as the simpler tinders. Quantities of peeled fungus of this kind have been found in excavations at Starr Carr in Yorkshire. These have been dated to about 7000 B.C. and as many flints and nodules of pyrites were also found it has been assumed that the fungus was collected and prepared for tinder[1].

Whether by wood friction or by sparks, firstly from flint and pyrites and later from flint and steel, the tinder could only be made to smoulder. It was then necessary to coax the smouldering material into flame. This could be done by blowing on it while carefully piling

[1] *Recent Archaeological Excavations in Britain*, edited by R. L. S. Bruce-Mitford. Routledge & Kegan Paul, London, 1956.

more tinder, but not too much, on the mass. Eventually, just as a flame may spring up from a smouldering bonfire on a windy day, the skilful operator would get a light. The time taken to do so was often a measure of his skill.

For pipe-smoking, which is a relatively modern requirement, the smouldering stage would suffice. Hence various optimistic estimates of the time spent in getting a light. A pipe could be lit in a few seconds, but a flame might take several minutes to coax out of the smouldering tinder and on damp days might be almost impossible to raise.

A short cut to flame-making was the sulphur match or 'spunk' which usually took the form of a splint of wood or a spill of paper or fibre coated at the end with a small quantity of yellow sulphur. The sulphur readily took fire from the glowing tinder and in turn set fire to the material of the match. The smell of sulphur dioxide is unpleasant, so it is possible that a stub of 1st-century Roman candle found at Vaison, near Orange in France, may have been a special candle for quickly kindling a light. The wick was impregnated with sulphur and although the Romans used scented lamps and possibly scented candles, it seems inconceivable that they can have enjoyed, or even tolerated, the smell of burning sulphur in a living-room. In a draughty corridor the sulphur-impregnated wick would be very difficult to blow out and this may have been the explanation of such an unpleasant candle. Another possible explanation is that it was simply a disinfectant.

It is very difficult to find the true meaning of some early references. In the Loeb classical series translations are confidently given of the following:

'hoc quod Transtiberinus ambulator, qui pallentia sulpurata fractis permutat vitreis.' Martial, *Epigrams,* I, XLI,

and

'nec sulpuratae lippus institor mercis.' ibid. XII, LVII.

It would be pleasing to accept the translator's versions:

'Just like the tramping hawker from beyond the Tiber who exchanges pale sulphur matches for broken glass,'

or:

'nor the blear-eyed huckster of sulphur wares.'

Are they matches? Are they pills such as are given to dogs today?

The match theory is probably fairly sound. Sulphur matches were known to be common domestic articles from the 17th and 18th century onwards. Cotgrave's French-English Dictionary of 1611 describes *Allumettes* as 'matches for tinder boxes'.

A moderately clear reference dates to the year 1626:[1]

'The maid is stirring betimes, and slipping on her shoes and her petticoat, groaps for the tinder box, where after a conflict between the steel and the stone, she begets a spark, at least the candle lights on his match; then upon an old rotten foundation of broken boards she erects an artificiall fabrick of the Black Bowels of New-Castle soyle, to which she sets fire with as much confidence as the Romans to their Funeral Pyles.'

The making of sulphur matches was quite easy as sulphur readily melted into a glutinous mass into which the splints could be dipped. Special sulphur-melting utensils, lipped to prevent boiling over into the fire, were common enough in the household.

In a curious little book, half-humorous, half-serious and very mannered, that was published in 1832 under the title *The Tinder Box* (William Marsh, London, 1832) there is a short chapter entitled 'the Match'. The ingredients are specified as 'dry pine wood, straight grained from Memel or America, and brimstone'. The inmates of common lodging-houses were said to beg suitable ends of wood from carpenters' shops and cut them up into slivers with bevelled ends. then, over a fire, they melted brimstone in 'a penny pipkin', being careful not to overheat it, and dipped their match-sticks a dozen at a time into the melted sulphur. Both ends were tipped and the matches left to cool. Twelve bundles, each of 12 matches, were said to sell for a penny so that not much of a living can have been made by the vendors, however industrious they may have been. The beggars selling matches in the streets today carry on the traditional association of match-selling and poverty, but they escape the toil of manufacture that made their forebears, in the words of the anonymous author of 1832, 'useful members of society with notions of dignity'.

Tinder itself was also the charge of the housemaid. She dried cotton or linen rags before the fire and charred them by setting them alight and then extinguishing them with the close-fitting interior lid of the tinder box. This was from the 18th century onwards but for centuries before that tinder was a household chore requiring universal diligence

[1] Nicholas Breton—*Fantasticks*, 1626 (London).

Without the sulphur match flame-making could be such a troublesome business that it was quite common to find savages and nomadic tribes going to great pains to transport the fire itself.

The most primitive method of fire-making, if not the first, was by wood friction. Three distinct groups of such apparatus are known. In the fire drill a hardwood rod is rotated rapidly on a softwood hearth. The rotation can be by hand or with the aid of a bow. The 'drill' bores a hole in the hearth and, by friction, can ignite eventually the powdered wood of the bore. In the fire-saw the hearth is cut by a sawing motion, using a hard split cane or sharp piece of wood. In the fire-plough the hearth is gouged out by continual rubbing with

Fig. 58. South Sea native, drilling for fire; Eskimo thong drill.

a ploughing action. In all three methods the wood had to be bone dry, and while the Eskimo employed virtually the same technique as equatorial tribesmen, the dryness and heat of the atmosphere were factors that could greatly simplify the operation.

Fire generated by wood friction became associated with the religious practices and was given a mystical significance. The Brahmins, in India, generated holy fire using nine different kinds of wood in the ceremony. The Parsis also regarded the wood-friction fire as of special significance. In Lemnos the Greeks extinguished all fires for seven days and then transported new fire from Delos. The fires in the Roman temple of Vesta had to be got from wood. Sanchoniatho, according to the transcriptions of Eusebius, attributed the discovery of fire from wood friction to Phlox, the third son of Genus. This was before either huts or clothing had been discovered, but is part of Phoenician legend rather than history.

Fire from sparks caused by striking a nodule of iron pyrites with

a sharp flint preceded the easier method of using a flint and steel. Evidence of this has been found in many stone and bronze age burial mounds. Iron was made in the Sudan at least as early as 1500 B.C. and gave a much hotter spark when struck by the flint. The sharp-edged flint cuts away small fragments of iron, the work done in the process heating the flying fragments to incandescence. This modern physical explanation is not in line with earlier ideas. Thus Virgil in *The Georgics*, I, 135 says 'silicis uenis abstrusum excuderet ignum' which may be translated as 'man learning to strike the lurking fire from veins of flint'. Shakespeare, also, regarded the fire as lurking in the flint. Thus:

'The fire in the flint shows not till it be struck.' *Timon of Athens*,

and the well-known words of Brutus:

> 'O Cassius, you are yoked with a lamb
> That carries anger as the flint bears fire
> Who, much enforced, shows a hasty spark
> And straight is cold again.'

Flint, steel and tinder were possessions of an essential order both in the home and in travel. The many varieties, shapes and designs of both the implements and their containers are not relevant to this work. The catalogue, by Miller Christy, of the Bryant and May Museum of Fire-Making Appliances, 1926, lists and illustrates what is probably the largest and fullest collection of such things. The collection is now exhibited in the Science Museum, London.

The sulphur match made it much easier to get a light from smouldering tinder, but the actual dropping of the spark on to the precise spot where the tinder could aptly receive it was a matter requiring a steady hand and a modicum of skill. In *The Tinder Box* (see p. 235), the author remarked that 'you cannot have blood out of a stone, but the stone can easily have blood out of you. On a cold dark frosty morning when the hands are chapped, frozen and insensible, you may chance to strike the flint against the knuckles for some considerable time without discovering your mistake'. Later he suggests that 'there are very few house-men, or house-maids, who can succeed in 'striking a light' in less than three minutes (this is the average result of many thousand experiments)', and while in daylight with perfectly dry tinder my own experiments have rarely taken so long it may well have been so in the cold and dark. No contradiction is possible of the anonymous author's suggestion that the state of the lungs was frequently impaired

by inhaling the fumes of burning brimstone, for that seems to be an inescapable part of the process of lighting a sulphur match.

Accuracy in placing the spark every time did not matter very much domestically, but was of vital importance to the gunsmith. In 1500 the process was mechanized in the wheel-lock guns made in Germany. A few years later similar devices were made as tinder boxes, but they were of elaborate workmanship and materials and were so expensive that they must have been available to the most important personages alone. The spark fired a small priming of gunpowder that in turn ignited a piece of amadou. The flint-lock pistol of the 17th century was a much simpler device, easier to work, and much more widespread. It was still not cheap enough to become the tinder box of the masses, but in various guises the design became common in the better-class houses. Some of them were combined with tapers, inkwells, pounce boxes, candle holders and even alarm clocks to provide special-purpose mechanisms for writing and sealing letters, lighting oneself out of bed and so on. For the masses, and indeed for ordinary use in most parts of the great houses, the simple tinder box containing a piece of flint, a hand-grip of iron, some bits of charred rag or other tinder and a flat plate to extinguish the smouldering matter, remained supreme. Separate compartments might be provided for the essential sulphur matches.

At this stage it is perhaps appropriate to pause a moment for reflection. If there were already a lighted lamp or candle in a room it was unnecessary to get a light from tinder. It was so much easier to get a light from a fire or from a lamp that spills were kept handy for just such a purpose, and special 'spill planes' were made in the later 18th century to cut thin slivers of wood which curled up into roughly tubular shapes. Flat wood spills like large matchsticks, and paper spills were also not uncommon.

When there was no fire handy the process of light-getting was far less simple. For the most part, lights were required only when it was dark, and often when it was very dark. It was in those conditions that the tinder box had to be found, the components identified by touch and the process of getting a light completed. That this could be a difficult matter is clear from the quotation already given[1] from Boswell's papers. He could not find the tinder box, the fire was out, so he had to sit in the dark. The value of the pocket tinder box becomes more apparent and the convenience of the tinder pistol easier to appreciate. The Japanese, typically, even went so far as to compress

[1] See p. 4

the mechanism of a tinder pistol into a space the size and shape of a walnut. These were worn as girdle ends, or netsuke. To the Tibetan the 'chuckmuck', which was simply a purse to contain flint and tinder with a fine steel as the framework, became almost a badge of rank. Some of these chuckmucks were highly elaborate, as also were some of the tinder pouches carried by Red Indians. All over the world the portable tinder pouch or box became a necessity.

From some time before 1786 the universal flint and steel found a competitor for the favour of the rich. This was the phosphoric taper, or ethereal match, an entirely chemical means of fire-making. This

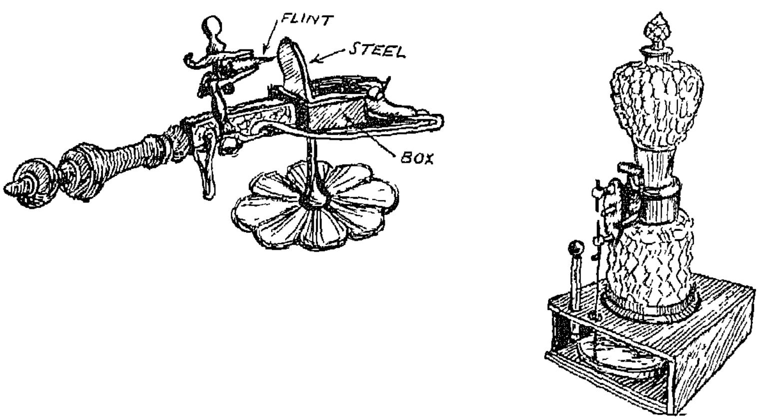


Fig. 59. Tinder pistol; Electro-pneumatic lamp.

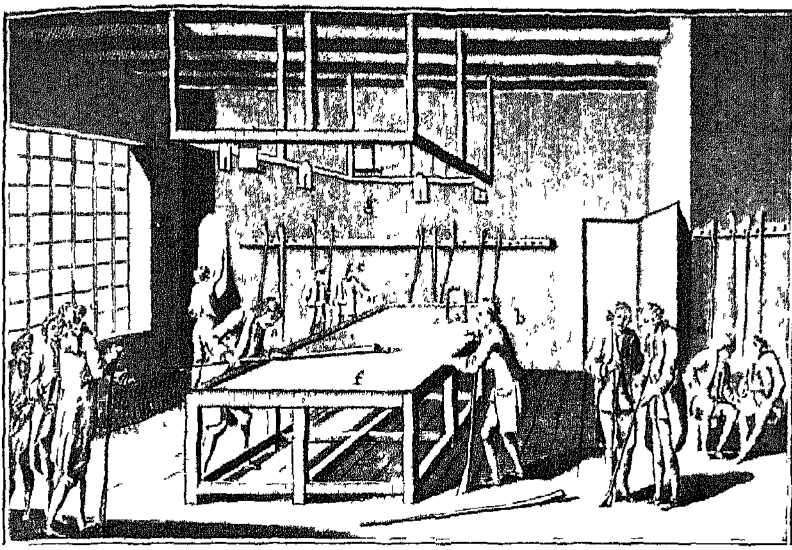
was not a very handy device, for the owner had to carry around a number of thin glass tubes about 4 inches long. In them was a short length of taper to which a small amount of phosphorus adhered. The tubes had a circular diamond scratch so that they could be broken easily. The taper could then be extracted and the phosphorus at its end would burst into flame spontaneously. The disadvantages of carrying around a number of easily broken glass tubes containing the means to spontaneous combustion hardly need description, and these expensive devices were never very popular, but in 1786 the phosphorus box proved more manageable. Sulphur matches were quickly introduced to and withdrawn from a stoppered bottle the sides of which were coated with phosphorus. The bottle was unstoppered and stoppered again quickly to keep out the air, but the little bit of phosphorus adhering to the end of the sulphur match was enough

to ignite it after a moment or two. These devices became moderately common in France and England.

The next chemical contrivance to be introduced was by no means portable. It was the 'Electro-Pneumatic lamp' patented in England by Lorenz in 1807 and made in Stettin by G. F. Schulz, who was probably the actual inventor. Hydrogen was generated in a modified Kipps apparatus and ignited by a spark of static electricity from an electrophorus, the plate of which was raised by the same press-button that opened the hydrogen jet. Very few of these have survived, probably because they were not only fragile but could explode if things went wrong. They were used in all probability more for lighting pipe-smokers' spills (like the universal gas-jet in the 19th-century tobacconists' shops) than for lamps. An example in the Science Museum, London was put into working order and without any attention gave a light unfailingly for three weeks every time the button was pressed. Later, in 1823, Professor Döbreiner of Vienna invented a similar device that bore his name and was made in fair quantities. Instead of an electrophorus providing a spark the hydrogen jet passed over some spongy platinum and ignited spontaneously. In modern times coal gas jets on cookers or gas lights have been lit in the same way.

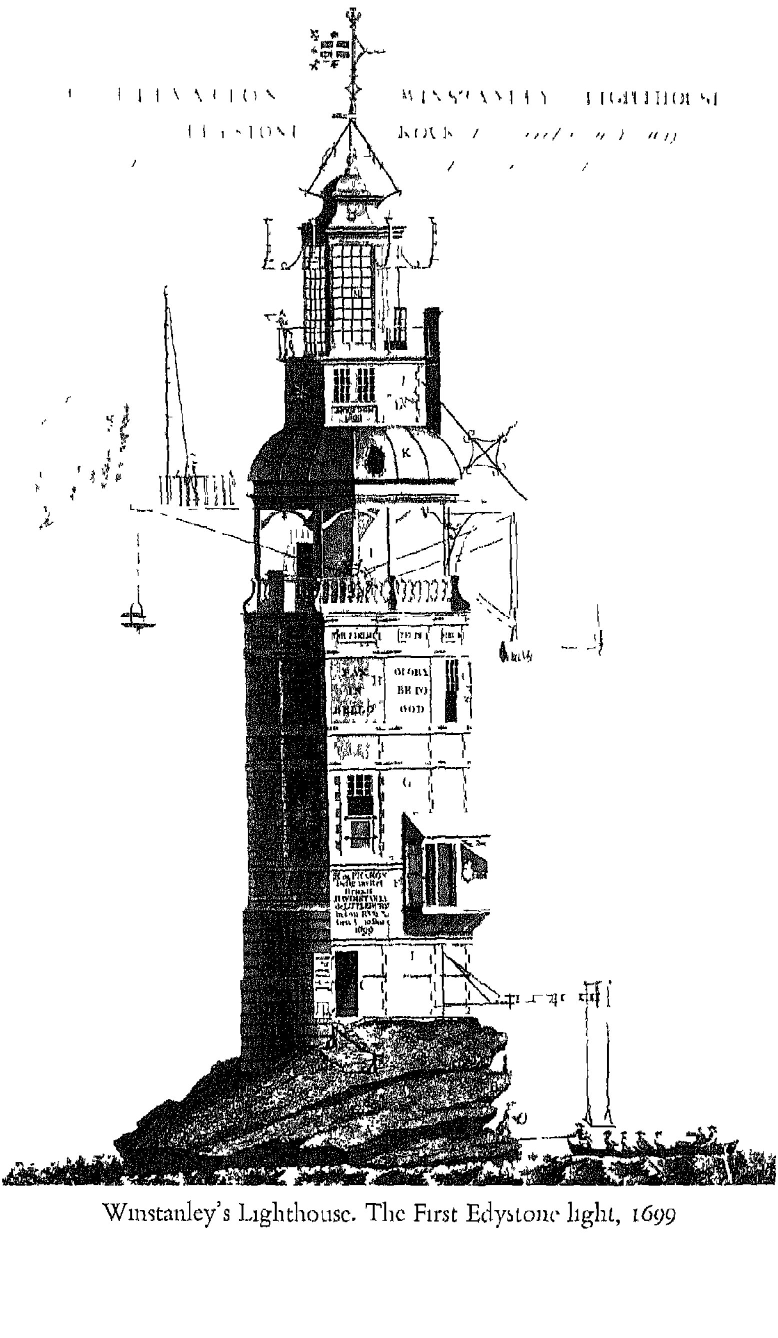
Perhaps the most popular of all chemical contrivances was the 'Instantaneous Light Box' introduced from France into England about 1810. Matches were made by dipping sticks into a mixture of chlorate of potash, sugar and gum. When these were inserted into a small phial of concentrated sulphuric acid and smartly withdrawn, they burst into flame. An advertisement for one such device known as 'Heitner's Eupyrium' gave the price of the cholorate matches alone at 1*s.* a hundred. It also remarked that 'in every family the tinder box is occasionally the subject of a malediction', but said nothing about the drops of vitriol that might inspire equally maledictory remarks about the eupyrium itself.

The fact that numbers of wealthy people should have been prepared to carry around with them small bottles of vitriol which, when a match was hastily withdrawn and even one drop was spilt, would burn through carpets, clothing or even skin, speaks sufficiently clearly of the contemporary difficulty in getting a light by other means. It was only in 1828 that Samuel Jones of London solved the difficulty of coping with vitriol by sealing single drops in tiny glass vesicles that were wrapped up in paper matches and broken with flat-nosed pliers when a light was wanted. These 'Promethean Matches' sold at a price much too high for any but the wealthy.



Billiards Table, 18th century (Diderot)

Westminster Pit, 1821 by I R and G Cruikshank



Winstanley's Lighthouse. The First Edystone light, *1699*

The 'Friction Light' was the invention of John Walker, a pharmacist of Stockton-on-Tees, England, in 1826. He dipped wooden splints into a paste made of chlorate of potash, sulphide of antimony, gum arabic and water. When dry the end could be nipped between a fold of sandpaper and would often ignite, when sharply withdrawn. His first recorded sale, in his daybook of April 7th, 1827, is of 100 'Sulphorata Hyperoxygenata' at 1*s.* plus 2*d.* for the tin. He neither patented nor greatly developed his invention and the same Samuel Jones of 'Promethean Match' fame copied them and sold them as 'Lucifers' in 1829. From Isaac Holden he got the idea later in the same year of adding free sulphur to aid combustion and Lucifers became so popular that there were many imitations in succeeding years. The use of phosphorus as in modern matches, was the idea of a Frenchman, Charles Sauria, in 1830; but like Walker he left it to others to develop a notable invention. Such matches became known as 'Congreves'. They were dangerously easy to ignite and workers with yellow phosphorus contracted a terrible occupational disease known as phossy jaw. Red phosphorus, which is harmless, was discovered by Professor Schrötter of Vienna in 1845, but its use in 'safety matches' was postponed until 1855 when Lundström of Sweden put the red phosphorus, which otherwise exploded when mixed with the other ingredients, on the rubbing surface outside the box.

'Strike-anywhere' matches could only be made without danger to workers after Sevène and Cahen, in France in 1898, discovered in sesquisulphide of phosphorus a harmless substitute for the noxious yellow form.

Pocket 'lighters' using cerium 'flints' and petrol as the fuel are common enough but in comparison with matches have an unimportant history. Originally, in the 19th century, 'amorce' lighters used percussion caps, but the introduction of petroleum in the second half of the century provided a lighter fuel with adequate properties.

Burning glasses, dependent on the sun, and that most extraordinary device of the natives of Borneo, the fire piston (igniting a small piece of tinder from the sudden compression of air in a close-fitting tube into which a piston is driven sharply) are curiosities more than effective instruments. So also was 'Gill's flameless lamp' described in 1818 as likely to come into general use as a night lamp for domestic purposes. A platinum spiral around and above the wick of an alcohol lamp would keep hot for eight hours after a lamp containing ½ oz. of alcohol was extinguished. German fungus (amadou) or prepared paper could be ignited from the red-hot coil.

Even in 1840, in Spain, fire from which to light a cigarette was hawked round the cafés of Madrid. Gautier described how '*ce feu, plus inextinguible que celui de Vesta, est porté par de jeunes drôles dans de petites coupes pleines de charbons et de cendres fines avec un manche pour ne pas se bruler les doigts*'[1] This seems a fairly good commentary on conditions before the friction match became commonplace (for although it may have been common in England and some other European countries by that time, transport was dangerous and it was not so readily bought in non-manufacturing countries such as Spain). By 1881, in Britain, Messrs. Bell and Black were making at least 80,000,000 wax vestas a day and two other firms in London alone were reputedly making at least the same quantity of matches of all kinds. Today, with matches being made in so many manufacturing countries, the daily output is astronomical. One large firm in Britain makes over 50,000 million matches every year, of which one-quarter are safety matches and three-quarters of the 'strike anywhere' type.

[1] This fire, as inextinguishable as that of Vesta, is carried by young urchins in little bowls full of charcoals and fine cinders, with a handle to protect the fingers from burning.

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General Index

Index of Dates

This supplements the general index and should be interpreted in conjunction with the chapter headings on pp. vii and viii and with regard to the following dates which were critical in the development of lighting techniques.

1782–4
The Argand burner for oil lamps.

1809
First permanent street lighting by gas.

1825–40
Great improvements in candles.

1858
Sugg gas burner did not deteriorate.

1860
Kerosene (Paraffin) from U.S.A. started an era of cheap and prolific supplies.

1870
The Gramme and subsequent electric machines made the arc lamp practical.

1880–85
Electric filament lamps and power stations such as Edison's (N.Y.C.) made electric light feasible for indoor use.

1890
Competitive power of gas restored by the incandescent mantle.

1903
The inverted gas burner.

1909
The ductile tungsten filament made electric lamps much better.

1913
Gas-filled lamps were better still.

1932
Sodium and mercury discharge lamps.

1940
Fluroescent tubes.

INDEX OF DATES